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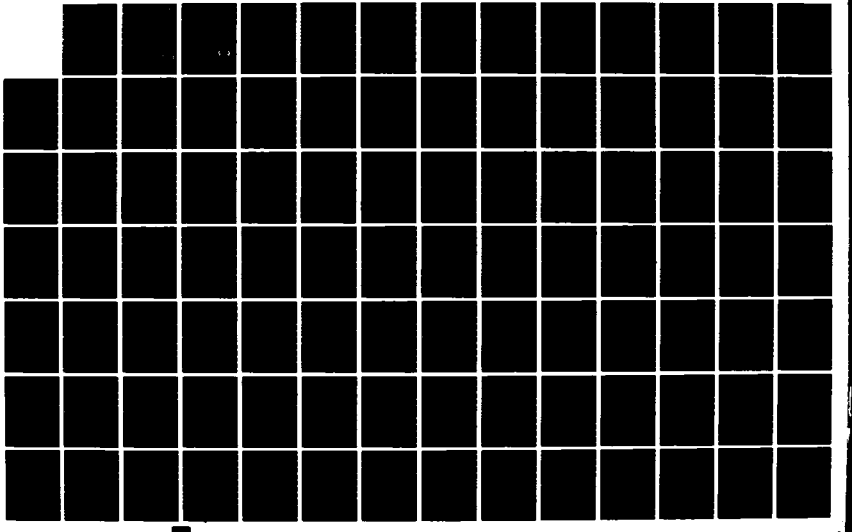

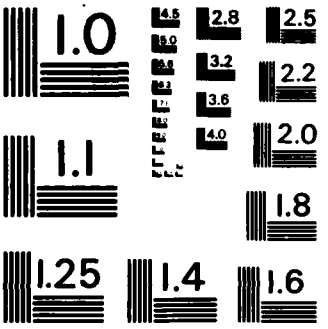

0209-2-LAB-1-Y-FINAL-VOL. II

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EVALUATION OF THE TRI-SERVICE LABORATORY SYSTEM

VOLUME II
NAVAL REGIONAL MEDICAL CENTER, OAKLAND

ARTHUR D. LITTLE, INC.
Acorn Park
Cambridge, Massachusetts 20140

June 20, 1983

Final Report for Period 2/17/82-6/20/83

Prepared for

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Results of the evaluation of the Tri-Service Laboratory (TRILAB) System at Naval Regional Medical Center, Oakland

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I. INTRODUCTION

A. PURPOSE

This report presents an evaluation of the Tri-Service Laboratory (TRILAB) System ~~installed by the Department~~ of the Navy at the Naval Regional Medical Center (NRMC) Oakland. This evaluation is based on comparison of post-implementation (Y-Period) data with baseline (X Period) data collected at the facility.

TRILAB is being implemented at three sites:

- Naval Regional Medical Center (NRMC) Oakland, California;
- Dwight D. Eisenhower Army Medical Center (DDEAMC), Augusta, Georgia; and
- Wright Patterson Medical Center and Regional Hospital, Dayton, Ohio.

NRMC Oakland was the first facility to receive the TRILAB system and was chosen as the primary evaluation site for the system. The original evaluation plan for the TRILAB system was developed by Analytic Services, Inc. (ANSER),[1] in 1980. Baseline data were collected under the supervision of ANSER staff during an eight-week period (September 29, 1980-November 29, 1980). Some of the data were analyzed by ANSER and summarized in their progress report.[2] The baseline data and progress report were provided to Arthur D. Little, Inc. (ADL). An assessment of the baseline data has been reported previously in a six-volume baseline report.[3]

This evaluation report concerning TRILAB at NRMC is the second volume in a four-volume report. This report is presented in four chapters:

- the remaining sections of this chapter describe the TRILAB system and operations of the clinical laboratory at NRMC Oakland during the baseline period and under the TRILAB system;
- the evaluation approach and data collection methodology are described in Chapter II;

- Chapter III presents the results of the post-implementation analysis and a comparison of results with the baseline data; and
- the final chapter compares the results obtained versus the original goals set for the system by the Medical Review Group (MRG).

B. DESCRIPTION OF TRILAB

The TRILAB system is designed to support the following laboratory activities: patient files, test order entry, specimen accessioning and control, work document preparation, quality control, test result entry, inquiry and data retrieval, test result reporting at wards and clinics, and management reporting.

The TRILAB system is designed to have automated, high-volume test instruments on-line, with the goal of significantly reducing clerical work of laboratory technicians and transcription errors. The system is also designed to monitor quality control samples in order to check for correct calibration of instruments and proper handling of the specimens within the laboratory, and to produce interim test results reports, daily cumulative reports, and cumulative summary discharge reports.

In addition, the system produces management information, such as laboratory workload summary reports, which should reduce the effort to prepare management reports and assist in the efficient organization and administration of the laboratory.

The TRILAB system, which uses software developed by Meditech and was obtained from Centennial Systems Corporation, through competitive procurement. The system can support terminals outside the laboratory, such as in wards, clinics and satellite facilities for transmission of results and for inquiry as to test status.

In addition to making results available via terminal inquiry, the TRILAB system produces a number of "hard-copy" (printed) reports:

(1) Summary Report by Location (SL). This is a cumulative summary report, organized by inpatient location, printed overnight and picked up at about 0400, to be available for physicians' morning rounds.

(2) Report by Doctor (RD). This is the largest report produced. It is a listing of daily outpatient results for inclusion in the outpatient medical record. This is sorted by physician's name and location, and then by terminal patient digit to facilitate filing by Outpatient Medical Records, which receives this report.

(3) Summary of Discharges (SD). This report, which is produced at inpatient discharge, summarizes all the patient's results for inclusion in the inpatient chart. It is ordered by inpatient terminal digit and is designed to replace the individual daily laboratory reports. It is organized one page per laboratory section, with all results for each type of test ordered by date from left to right in a single line.

(4) Outpatient Requesting Report (OPR). This report is sorted by outpatient requesting location, physician, and alphabetically by patient. In consists of one page per patient, is not designed to be filed in the chart, and is sent to the requesting clinics.

(5) Outstanding Specimen Report (OSR). This is an internal laboratory management report, sorted by section.

(6) Review Results Log (Micro). This is essentially a patient listing log for the Cytology section, which must maintain a hard-copy log for epidemiological purposes.

(7) Report by Location (RL). This is an interim daily report for inpatients, similar in format to the OPR, but not cumulative, and is designed only for those inpatient units which may have pre-operative patients. It is available at 1900.

(8) Levey-Jennings. This report is printed on weekends when system usage is low and other reports are not produced. This report consists of plots and results obtained for control tests by day for the past month, and the standard deviations identified so that number and trends of outliers can be easily (visually) identified.

C. DESCRIPTION OF OPERATIONS OF THE CLINICAL LABORATORY AT NRMC OAKLAND

1. Overview

NRMC Oakland is a large medical treatment facility (MTF), with an average daily inpatient census of 244 patients and service volume of 376,326 outpatient visits per year (FY 1982). This compares with an average census of 234 and outpatient volume of 396,621 visits in FY 1980. During FY 1982, the clinical laboratory performed approximately 2,586,000 tests (including quality controls) compared with 2,642,000 tests in 1980. Laboratory workload has thus remained relatively stable between the baseline and post-implementation periods. During October 1982, when the post-implementation data collection effort was carried out, the laboratory performed 170,150 patient tests (excluding quality control). This is 15 percent greater than the 147,625 tests reported performed in October 1980 (when the baseline survey was carried out).

Clinical laboratory staffing during the two periods was as follows:

	April 1980		October 1982	
	Authorized	Assigned	Authorized	Assigned
Pathologists	6	8	6	5
Pathology residents	8	9	8	5
Medical Service Corps (MSC) laboratory officers	5	5	5	5
Military laboratory technicians	59	41	52	44
Civilian laboratory technicians	23	23	27	29
Civilian receptionists/ secretaries	4	4	4	2
Total	105	90	102	90

The assigned staff of 90 includes 71 technical personnel. In 1980 there were also 90 assigned personnel, including 67 technical personnel.

The laboratory operates during all shifts, all days of the week. However, the staffing is greatly reduced on nights, weekends, and holidays. The work day is divided into three shifts, with the primary responsibility for the evening and night shifts being the handling of urgent and emergency tests requests.

The laboratory is divided into six major sections:

- Hematology/Urinalysis (includes Special Hematology),
- Chemistry,
- Special Chemistry (located outside the main facility),
- Blood Bank,
- Microbiology (includes Mycology, Serology, and Parasitology), and
- Anatomical Pathology (includes Histopathology, Autopsy, and Cytology).

Additionally, laboratory test procedures are performed in the Radio-Immunoassay Laboratory (staffed by Nuclear Medicine Department personnel and located in the clinical laboratory) and in the Cardiopulmonary Laboratory (staffed by Medicine Department personnel and located on the fourth floor of the facility).

2. Baseline Work Flow

The typical procedure for handling test requests and reports prior to implementation of TRILAB is described below. Figure 1 presents a flow diagram schematic of the information and test flow.

An authorized health care provider (HCP) ordered laboratory test procedures using order requisition forms--generally one for each section of the laboratory. Authorized HCPs (those who may order laboratory procedures for a patient) included physicians, dentists, nurse practitioners, and physician assistants. The ordering HCP could prepare the test request slip, or the HCP could delegate this task to a nurse, corpsman, or unit clerk.

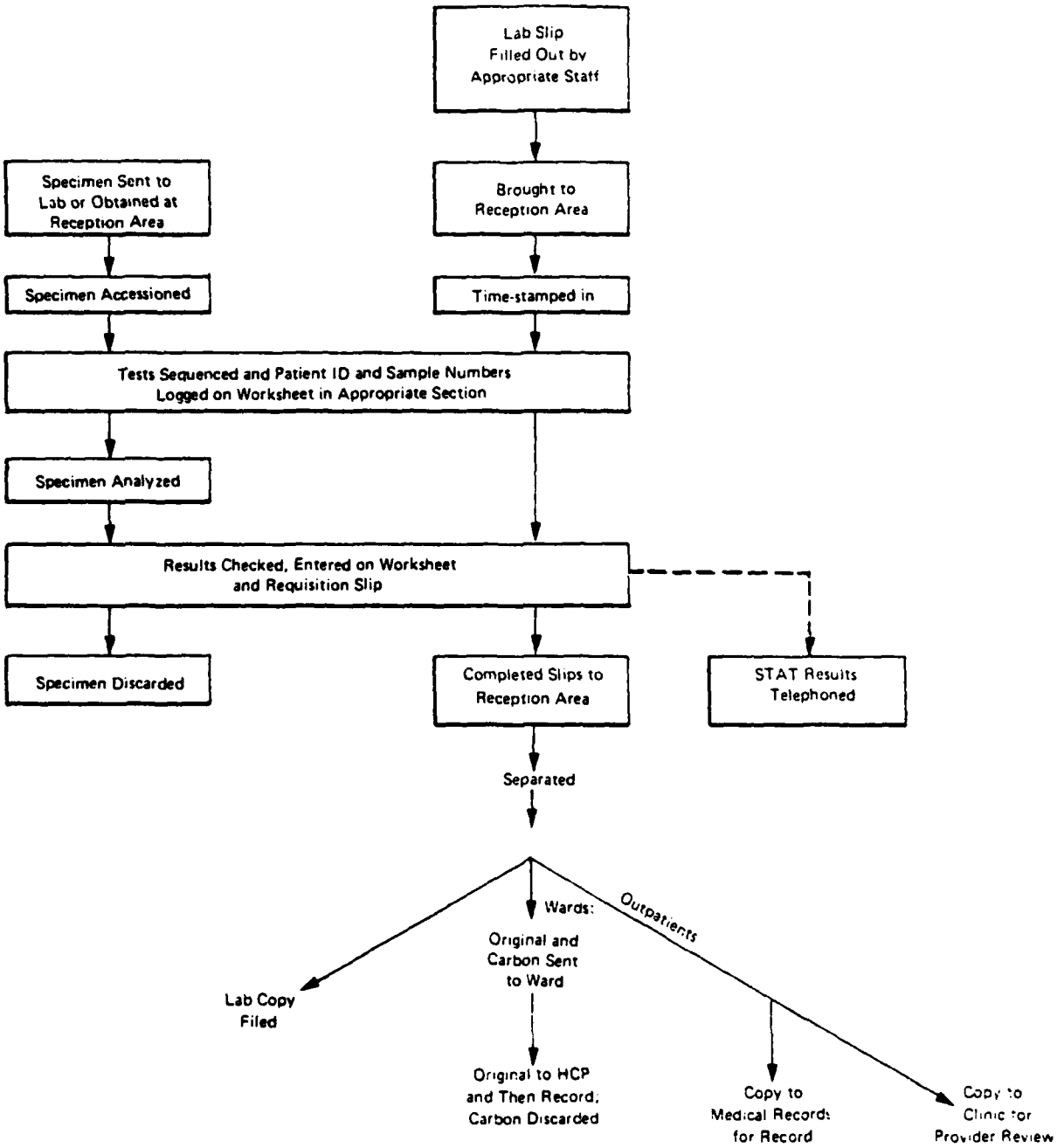


FIGURE 1 INFORMATION FLOW PROCESS, CLINICAL LABORATORY, NRMC OAKLAND OCTOBER 1980 (Baseline)

Outpatients and ambulatory inpatients carried the prepared test request slip to the laboratory where the required specimens(s) were collected. The laboratory receptionists controlled specimen collection for outpatients and ambulatory inpatients. Specimen collection for nonambulatory inpatients was performed on the ward, mainly by ward personnel, with subsequent transport of the specimen and request slip to the laboratory by ward personnel. (This part of the system is the same with TRILAB as under manual operations.)

After the test request slip and specimen were brought to the appropriate laboratory section, a technician accessioned and logged each specimen received or collected by the section. Depending upon the test priority stated by the HCP and indicated on the slip, a technician processed the test immediately or at a later time. The three types of test priority were routine (normal processing), urgent or "ASAP" (results required faster than normal), and emergency (STAT) results required immediately). For each instrument run, a "worksheet" was prepared, which listed the sequence of patient specimens to be processed and the tests to be performed on each. The laboratory technician, having performed the appropriate test procedures, arrived at a preliminary, uncertified result. The results were copied onto the worksheet. Following certification (validation) of the preliminary result by the laboratory section supervisor, the certified test result was communicated to the requesting location. Laboratory personnel immediately telephoned certified results of urgent and emergency tests to the requesting HCP.

Results of all tests were recorded in the multiple-copy requisition form, which was separated and routed to various destinations within the facility. The routing sequence differed for outpatients and inpatients. For outpatients, the top copy (the "original") of the slip went to Outpatient Medical Records for filing in the patient's Outpatient Health Record; the second copy of the slip went to the clinic requesting the test procedure (where the HCP reviewed it); and the third copy of the slip was retained and filed in laboratory files

located in the reception area. For inpatients, the top copy of the slip was sent to the requesting ward, where the HCP reviewed it and the slip was incorporated into the patient's Inpatient Health Record; the second copy of the slip was discarded; and the third copy of the slip was retained and filed in the laboratory.

3. TRILAB Configuration

The TRILAB system obtained for NRMC Oakland included a mainframe computer with 512 KB memory, two 96 MB disks and an 800 BPI tape unit. Peripherals included 42 CRTs, seven character printers, and one line printer. Eighteen of the terminals were located in patient care areas. Six terminals were located in outpatient areas: the Emergency Room, and the Obstetric, Cardiopulmonary, Medical/Dermatology/-Cardiology, Surgical and Primary Care Clinics. Twelve terminals were located in inpatient areas: The CCU, 8W, Recovery, ICU, PICU, 6N, 6W, 9, 7N, 9W, 7E and 8S units. Two CRTS were located in Inpatient Admissions, two in the Outpatient Admissions area and the remainder in the laboratory. The line printer and one character printer were located in the computer room; the remaining six printers were located in the laboratory area.

The only instruments which were on-line to the computer were the SMAC, Coulter S+, and Clintech, although interfaces were also obtained for the Gemini, Coagamate, and electrolyte instruments.

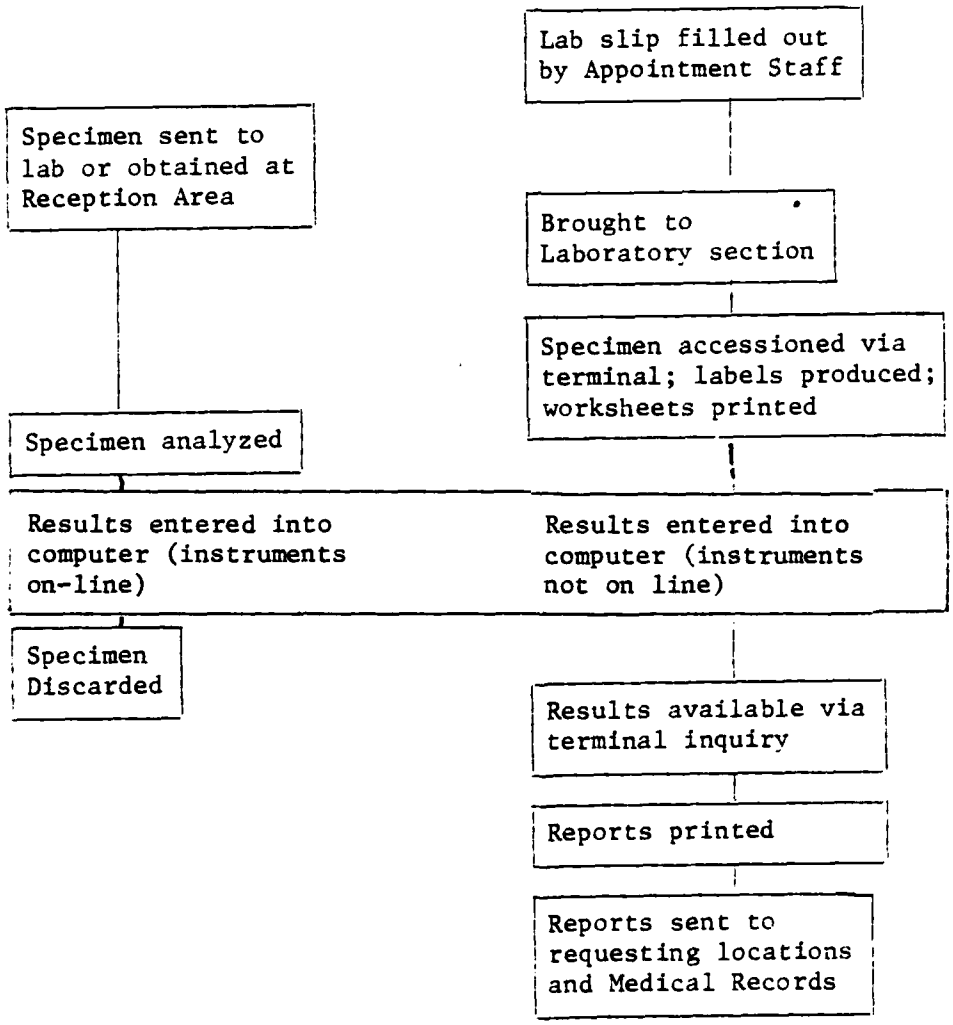
4. Post-Implementation Work Flow

Figure 2 presents a flow diagram schematic of the information and test flow during the post-implementation period. Preparation of laboratory test requests and transportation of specimens to the laboratory was the same as in the baseline period.

Within each laboratory section, a technician "accessioned" each test request via terminal in each section by looking up the patient's record and entering the requested tests. In most instances the patient's record should be in the file, having been pre-admitted by Outpatient or Inpatient Admissions. In those cases where a patient's name was not in the file, the laboratory technician created a patient record, including required demographic information. The computer was

FIGURE 2

INFORMATION FLOW PROCESS, CLINICAL LABORATORY
NRMC OAKLAND
OCTOBER 1982



then utilized to generate labels where appropriate (e.g., in Microbiology) and worksheets, which list for each instrument the patients and required tests.

Tests were performed in the following order of priority:

- "emergency" or STAT (results required immediately);
- urgent or "ASAP" results (results required faster than normal);
- routine inpatient; and
- routine outpatient.

For those instruments and tests which were not on-line to the computer, the results were entered manually on the worksheet and then entered into the computer via a terminal, in worksheet format. For the on-line instruments, the results were automatically entered in the computer.

The results were then reviewed via a "Results Review Program"--that is, verified by supervisory personnel--and were then available for requester inquiry via terminal at any location where the terminals were located. In the case of STAT/urgent requests, the terminal in the requester's location "beeped" to inform the unit or clinic that a STAT result was available. When a request slip included multiple tests some of which were "emergency" or "STAT," all tests on the slip received this designation, but only the true emergency or STAT tests were "beeped" back on completion, with the remaining tests receiving routine handling.

The "interim results report" was printed by the computer in the late afternoon for some 10 inpatient units which were likely to have pre-operative patients. This report, scheduled to be available by 1900 hours, consisted of one page per patient and included the results of tests performed during the previous 24 hours. During the night shift the daily summary inpatient and outpatient reports were printed, which were picked up at around 0400 hours for dissemination to inpatient units and outpatient clinics.

As mentioned earlier, a number of other reports were produced by the TRILAB system, including the "summary of discharge" report, which summarized all patient's results for inclusion in the inpatient chart

on discharge; the "outstanding specimen" report, which was utilized internally by laboratory management to follow up on specimens for which completed results were not yet available; the "review results log" for Microbiology; the "Levey-Jennings report," which was printed in weekends and was utilized by the laboratory for quality control analysis; and the "workload summary" report, which summarized tests performed by each section.

The major differences between the baseline (manual) system and the post-implementation (TRILAB) system were:

- Providers in locations provided with terminals received results via terminal as soon as they were available, instead of having to wait for telephone calls (in the case of STAT and urgent requests) or the completed test request slip (in the case of routine requests).
- the reports received by providers were cumulative, formatted and on full-size paper, instead of the original request slips. Medical Records received a single cumulative discharge report for inpatients, rather than a number of slips for each day's tests that were carried out during a patient's stay.
- Within the laboratory, work sheets were prepared by the computer after tests had been accessioned, instead of being prepared manually.
- For those instruments which were not on-line to the computer, technicians entered results into the computer memory via terminal, instead of writing the results on the original test request slips. For those instruments which were on-line, the results were automatically entered into the computer memory. Review of test results was expedited in that normal values and outliers were automatically identified, as well as unusual changes from previous patients' test results.
- The computer produced a number of management reports for the laboratory which previously were prepared manually.

- Test status and results could be obtained via inquiry from any terminal connected to the system, instead of by looking up records or phoning the laboratory.

II. METHODOLOGY

This chapter presents a summary of the baseline and post-implementation period evaluation plans for NRMC Oakland. A more complete description of the baseline evaluation plan is presented in the report, "Baseline Evaluation of the Tri-Service Laboratory System Volume II,"[3] and of the post-implementation evaluation plan, in the report "Plan for the Y Period Evaluation of the Tri-Service Laboratory System."[4]

The baseline evaluation plan for the TRILAB system, developed by Analytic Services, Inc. (ANSER)[1] described 36 hypotheses regarding the potential impacts of TRILAB on the clinical laboratory and the MTF. These were grouped into the following four areas:

- personnel time;
- satisfaction and perception;
- information attributes; and
- costs.

The evaluation called for a before-and-after study comparing manual laboratory operation with operation of the laboratory using the TRILAB computer system. Two periods of data collection were planned: the baseline period with manual operation before the installation of TRILAB; and the post-implementation when TRILAB was operational. This before-and-after approach was followed in the plans for the three TRILAB evaluations.

Table 1 summarizes the evaluation elements and data collection methods used in the baseline evaluation at NRMC Oakland. Four types of data were collected by ANSER during the baseline study at NRMC Oakland:

- time spent by personnel within the laboratory in information handling activities (using work sampling and timed observations);
- performance of services (turnaround time for test results in the laboratory; transcription discrepancies; number of telephone inquiries about test results; and patient waiting time);

TABLE 1

EVALUATION ELEMENTS AND DATA COLLECTION METHODS FOR BASELINE EVALUATION OF THE TRI-SERVICE LABORATORY SYSTEM AT NRMC OAKLAND

Element	Data to be Obtained	Data Collection Methodology	Data Obtained
Personnel Time Devoted to Information Handling	Time devoted to information handling activities, e.g., accessioning, logging, result preparation in: Chemistry, Hematology, Bacteriology	Work sampling	Percent of time and manhours per week by activity type[a]
	Blood Bank, Reception Area	Timed observations	Percent of time (minutes per activity)--day shift, weekdays
Service Performance			
• Turnaround Time	Time from requisition to result avialability	Time stamp laboratory requisitions at two points in process	Lab process times for Chemistry tests (routine and STAT) Hematology tests (routine and STAT) Bacteriology tests
• Transcription Discrepancies	Number of transcription discrepancies	Medical Record Review	Percent of transcriptions with discrepancies
• Lab Inquiries	Volume and type of telephone calls to laboratory	Monitoring and categorizing of calls	Volume of telephone calls by type (day shift, week days)
• Patient Waiting Times	Waiting times at reception desk	Timed observations of patients waiting in reception area	Average patient waiting time*
Staff Perceptions of Laboratory Services	Perceptions of providers, nursing and lab staff	Self-administered questionnaire	Perception ratings using Likert Scale
Patient Satisfaction with Laboratory Services	Patient satisfaction with lab services	Self-administered questionnaire	Satisfaction ratings using Likert Scale

[a]Data analyzed by Analytic

- staff perceptions of performance of services (staff questionnaire survey); and
- staff and patient satisfaction (staff and patient questionnaire survey).

The post-implementation evaluation plan was developed with the following considerations:

(1) In order to utilize the baseline data to the maximum extent, and to make the before-and-after comparison as consistent and meaningful as possible, the same evaluative measures, data collection methodologies, and data collection instruments used in the baseline period were used in the post-implementation study to the extent possible. It was necessary, however, to modify the data collection methodology and instruments in several instances, in view of the differences in procedures in the laboratory because of the TRILAB system.

(2) Sample sizes were chosen to provide as reliable as possible data, given the data available from the baseline evaluation.[2]

(3) Where the baseline data were unavailable or insufficient for evaluation purposes, an effort was made to collect such information via interviews and review of any available reports.

The post-implementation data collection plan was organized under the following data collection methodologies:

(1) Work sampling at NRMC Oakland, to collect data on distribution of laboratory personnel activities in the post-implementation period for comparison with distribution of activities in the baseline. The major objective was to determine whether time spent in information handling activities had changed.

(2) Process time study at NRMC Oakland and DDEAMC to determine whether process times for return of test results had changed.

(3) Volume of telephone calls to the laboratory at NRMC Oakland and DDEAMC, to determine whether changes had occurred in the volume of telephone inquiries to the laboratory as a result of the availability of results via the TRILAB system.

(4) Surveys of laboratory staff, providers, and patients, to determine whether satisfaction with clinical laboratory services had changed.

(5) Interviews and supplementary data collection, to obtain cost data, volume data, and other information.

Table 2 summarizes the relationship between the evaluation elements and the data obtained in the post-implementation study.

The basic data for the post-implementation evaluation at NRMC Oakland were collected during an intensive study period, October 8-22, 1982. (No data were collected on Columbus Day, October 11, since the holiday was considered unrepresentative of normal laboratory activities.) The data collection period was thus two years after the baseline data collection (October-November 1980) and eight months after initiation of the TRILAB system implementation. In addition to data collection and interviews during this study period, three implementation monitoring visits were made prior to the study period (in March, May and August 1982), during which laboratory staff and providers were interviewed. The results of these interviews were also used in the evaluation.

TABLE 2

TRILAB EVALUATION ELEMENTS AND DATA COLLECTION METHODS
POST-IMPLEMENTATION EVALUATION

Element	Data to be Obtained	Data Collection Methodology	Data Obtained--NRMC Oakland
Personnel Time Devoted to Information Handling	Time devoted to information handling activities, e.g., accessioning, logging, result preparation in: Chemistry Hematology Bacteriology	Work sampling	Percent of time and manhours per week by activity type
Performance of Services			
• Turnaround Time	Time from requisition to result availability	Computer Inquiry	Laboratory process times for Chemistry tests (routine and STAT) Hematology tests (routine and STAT) Bacteriology tests
• Transcription Discrepancies	Number of transcription discrepancies	Interviews with laboratory supervisory staff	Estimates of changes in errors
• Laboratory Inquiries	Volume and type of telephone calls to laboratory	Monitoring and categorizing of calls	Volume of telephone calls by type (day shift, weekdays)
Staff Perceptions of Laboratory Services	Perceptions of providers, nursing and laboratory staff	Self-administered questionnaire	Perception ratings using Likert scale
Staff and Patient Satisfaction with Laboratory Services	Staff and patient satisfaction with laboratory services	Self-administered questionnaire	Satisfaction rating using Likert scale

III. RESULTS

A. INTRODUCTION

This chapter summarizes and compares the results of the baseline and post-implementation studies at NRMC Oakland. The evaluation is organized under the following topics:

- Personnel Time Devoted to Information Handling;
- Service Performance (turnaround times, number of telephone calls);
- Staff Perceptions of TRILAB;
- Patient Satisfaction with Laboratory Services;
- System Costs.

The comparison of the results obtained in the baseline and post-implementation periods is complicated by the following factors:

- The baseline and post-implementation data collection studies were conducted by different contractors; the original evaluation plan, baseline data collection and some of the baseline data analysis were performed by ANSER, while the remainder of the baseline data analysis, and the post-implementation plan and data collection were conducted by Arthur D. Little, Inc. This resulted in some difficulty in interpretation of the baseline data; for example, it was not clear whether the total times estimated for information handling and other activities in the baseline period (Section B) referred to all shifts and days of the week, or only for the weekday shifts (when the work sampling data collection was mainly carried out).
- Although as indicated in Chapter I, total laboratory workload and staffing has remained relatively stable between the baseline and post-implementation study periods, staff have been reassigned among laboratory sections. Staffing of Chemistry and Microbiology decreased, while staffing in Hematology increased. The differences in staffing levels, however, are subject to uncertainty because of difficulties in interpretation of the estimates of staffing levels during the baseline sampling period.

- The Hematology section obtained a new Coulter S+ instrument between the baseline and post-implementation study periods. The new instrument has a higher throughput rate than the former Coulter instrument in the laboratory.

Despite these complications, the results obtained in the baseline and post-implementation studies appear sufficiently consistent that conclusions can be drawn, albeit with some degree of uncertainty.

B. PERSONNEL TIME DEVOTED TO INFORMATION HANDLING

1. Introduction

In the baseline study, time spent by laboratory personnel in information handling activities within the laboratory was determined by an extensive work sampling program conducted in the three major laboratory sections: Chemistry, Hematology, and Microbiology. Thirteen information handling activities were defined for work sampling purposes:

- verify and correct result request slips;
- accession specimens;
- prepare worksheets;
- perform test calculations;
- record test results;
- transcribe test results;
- report test results;
- distribute test results;
- file test results;
- respond to inquiries on test status;
- compile workload statistics;
- maintaining quality control information; and
- process incoming and outgoing specimens.

Four additional activities were utilized to measure time devoted to activities other than information handling:

- process test results (perform tests);
- other productive work;
- other non-productive work (socializing, nonbusiness use of telephone); and
- away from area.

The data were collected mainly during the daytime shift (primarily 0700 to 1600) and on weekdays, during an eight-week period.

In order to compare the time spent by laboratory personnel on information handling activities after the installation of the TRILAB system, the work sampling program was repeated during the post-implementation study. Seven additional activities were defined to account for computer-related activities:

- maintain computer system;
- accession specimens;
- prepare worksheets;
- results entry;
- results retrieval;
- results review; and
- edit files.

The definition of the work sampling activities and the data collection forms are provided in Appendix A.

In order to obtain data comparable to that collected in the baseline period, work sampling was performed during the day shift, from 0730 to 1600, on weekdays, for a 10-day period between October 8-22, 1982. Data collectors were each trained in activities of two laboratory sections and traded areas for part of each day. Quality control of the data collection was monitored by frequent checking by the data collection supervisor.

2. Baseline Results

The results of the baseline work sampling are summarized in Table 3. The detailed results are presented in Tables 4 ,5 and 6.[2] Approximately 52,000 observations were made (21,000 in Chemistry,16,000 in Hematology, and 14,500 in Microbiology).

Approximately 28 percent of laboratory staff time was devoted to information handling activities during the sampled periods (Table 3), estimated to account for a total of 410 manhours per week. The ANSER report does not indicate how the estimates of weekly hours per activity were calculated, nor does it provide staffing levels by shift.

TABLE 3

SUMMARY OF WORK SAMPLING RESULTS
BASELINE EVALUATION AT NRMC OAKLAND

Laboratory Section	Observations	Hours/Week	Time Spent in Information Handling Activities	
			Percent	Hours/Week
Chemistry	21,171	639.1	37.3%	238.4
Hematology	16,063	378.2	18.1	68.0
Bacteriology	14,533	458.3	22.6	103.5
	51,767	1,475.6	27.8	409.9

TABLE 4

SUMMARY OF BASELINE WORK SAMPLING RESULTS FOR THE CHEMISTRY SECTION OF THE CLINICAL LABORATORY AT NRMC OAKLAND

Activity Measured	Number of Observations	Percent of Total Time Spent	Manhours Spent (per week)
Verify and correct result request slips	95	0.4	2.9
Accession specimens	2705	12.8	81.7
Prepare worksheets	360	1.7	10.9
Process test results	4191	19.8	126.5
Perform test calculations	146	0.7	4.4
Record test results	361	1.7	10.9
Transcribe test results	756	3.6	22.8
Report test results	124	0.6	3.7
Distribute test results	386	1.8	11.7
File test results	218	1.0	6.6
Respond to inquiries on test status	394	1.9	11.9
Compile workload statistics	611	2.9	18.4
Maintain quality control information	1227	5.8	37.0
Process incoming and outgoing specimens	514	2.4	15.5
Other productive work	2556	12.1	77.2
Nonproductive time	1038	4.9	31.3
Away from area	5489	25.9	165.7
Maintain computer system	--	--	--
	21171	100.0%	639.1 TOTAL

Source: Analytic Services, Inc. (ANSER), "Progress Report, Period X Data Analysis for the Evaluation of the Tri-Service Laboratory Initial Capability System (TRILAB) at the Naval Regional Medical Center Oakland, California." Contract No. MDA 903-78-C-0085. Report to the Tri-Service Medical Information Systems Program Office, Bethesda, MD, January 1981.

TABLE 5

SUMMARY OF BASELINE WORK SAMPLING RESULTS FOR THE HEMATOLOGY SECTION OF THE CLINICAL LABORATORY AT NRMC OAKLAND

Activity Measured	Number of Observations	Percent of Total Time Spent	Manhours Spent (per week)
Verify and correct result request slips	58	0.4	1.4
Accession specimens	1077	6.7	25.4
Prepare worksheets	73	0.5	1.7
Process test results	4829	30.1	113.7
Perform test calculations	31	0.2	0.7
Record test results	159	1.0	3.7
Transcribe test results	466	2.9	11.0
Report test results	111	0.7	2.6
Distribute test results	156	1.0	3.7
File test results	119	0.7	2.8
Respond to inquiries on test status	286	1.8	6.7
Compile workload statistics	142	0.9	3.3
Maintain quality control information	189	1.2	4.4
Process incoming and outgoing specimens	24	0.1	0.6
Other productive work	1435	8.9	33.8
Nonproductive time	287	1.8	6.8
Away from area	6621	41.2	155.9
Maintain computer system	--	--	--
	16063	100.1%[a]	378.2 TOTAL

Source: Analytic Services, Inc. (ANSER), "Progress Report, Period X Data Analysis for the Evaluation of the Tri-Service Laboratory Initial Capability System (TRILAB) at the Naval Regional Medical Center, Oakland, California." Contract No. MDA 903-78-C-0085. Report to the Tri-Service Medical Information Systems Program Office, Bethesda, MD, January 1981.

[a]Due to rounding.

TABLE 6

SUMMARY OF BASELINE WORK SAMPLING RESULTS FOR THE MICROBIOLOGY SECTION OF THE CLINICAL LABORATORY AT NRMC OAKLAND

Activity Measured	Number of Observations	Percent of Total Time Spent	Manhours Spent (per week)
Verify and correct result request slips	40	0.3	1.3
Accession specimens	1530	10.5	48.2
Prepare worksheets	50	0.3	1.6
Process test results	4230	29.1	133.4
Perform test calculations	10	0.1	0.3
Record test results	348	2.4	11.0
Transcribe test results	442	3.0	13.9
Report test results	145	1.0	4.6
Distribute test results	123	0.8	3.9
File test results	118	0.8	3.7
Respond to inquiries on test status	247	1.7	7.8
Compile workload statistics	51	0.4	1.6
Maintain quality control information	128	0.9	4.0
Process incoming and outgoing specimens	52	0.4	1.6
Other productive work	1600	11.0	50.5
Nonproductive time	502	3.5	15.8
Away from area	4917	33.8	155.1
Maintain computer system	--	--	--
	14533	100.0%	458.3 TOTAL

Source: Analytic Services, Inc. (ANSER), "Progress Report, Period X Data Analysis for the Evaluation of the Tri-Service Laboratory Initial Capability System (TRILAB) at the Naval Regional Medical Center Oakland, California." Contract No. MDA 903-78-C-0085. Report to the Tri-Service Medical Information Systems Program Office, Bethesda, MD, January 1981.

Review of the raw data work sampling sheets indicated that staff work sampled included the technicians assigned to the three departments, including trainees, and excluded supervisors, officers, and secretaries. The hours per week reported in Table 3 are equivalent to average staffing of 37, 16, 9.5 and 11.5 for Chemistry, Hematology and Microbiology, respectively--assuming 40 hours per week per FTE. It is not clear whether this staff was for all shifts and days of the week, or for the weekday shifts only. The sections demonstrated a wide variance in proportion of information handling time: 37 percent in Chemistry, compared with 20 percent in Hematology and Microbiology. Conversely, about 20 percent of staff time in Chemistry was devoted to actual test processing, compared with 30 percent for Hematology and Microbiology.

In the Chemistry Section, 26 percent of staff time was spent away from the area, reflecting 164.7 manhours per week. This time included personal time, time when the laboratory was being cleaned, and filing time in the reception area. Data collected in the Microbiology section showed staff away from their area 34 percent of the time. A portion of this was due to staff being required to spend time in the refrigerated media room, which was located on another floor. Hematology staff were away from the area a substantially greater proportion of time (41.2 percent). This was attributed to the time spent by Hematology staff in assisting in the phlebotomy and reception areas, which were physically near the Hematology laboratory.

Another activity which required a proportionately large percentage of time was the processing of test results. This was evident in all three sections of the laboratory--Hematology: 30.1 percent of time or 113.7 manhours/week; Microbiology: 29.1 percent of time or 133.4 manhours/week; and Chemistry: 19.8 percent of time or 126.5 manhours/week. Accessioning specimens also required a proportionately large amount of time.

Finally, a significant amount of time in all three sections was spent transcribing test results--Chemistry: 3.6 percent of time or 22.8 manhours/week; Hematology: 2.9 percent of time or 11.0 manhours/

week; and Microbiology: 3 percent of time or 1.39 manhours/week. In addition, data collected in the Chemistry section of the laboratory indicated significant time was devoted to compiling workload statistics and maintaining quality control information--18.4 and 37.0 manhours, respectively. The time spent maintaining quality control information reflected the assignment of 100 percent of one staff member's time performing only workload calculations and quality control analysis.

Further interpretation of these data and translation into a form suitable for comparison with data collected in the post-implementation study was made difficult by the lack of data on staffing and workload processed by the three sections during the eight-week sampling period (i.e., day shift, weekdays).

3. Post-Implementation Results

The results of the post-implementation work sampling are summarized in Table 7. The detailed results for each of the sections (Chemistry, Hematology, and Microbiology) are presented in Tables 8, 9 and 10. The only planned difference between the work sampling in the two study periods was that the Nuclear Medicine section was not included in the post-implementation work sampling, because the TRILAB system was only partially implemented there and section activities were, therefore, not considered representative of those when the system will be fully implemented in that section.

Approximately 29,000 observations were obtained, approximately one third in each of the major sections. Because the computer was down for virtually one complete day during the data collection period, however, the results for that day were omitted from subsequent calculations as being unrepresentative of normal operations with the TRILAB system. This resulted in some 26,000 observations considered useful (Table 7).

Approximately 24.6 percent of laboratory staff time was devoted to information handling activities during the sampled period (Table 7). As in the baseline period, percent of time devoted to information

TABLE 7

SUMMARY OF POST-IMPLEMENTATION WORK SAMPLING RESULTS
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

Section	Number of Observations[a]	Total Hours/Week	Time Spent in Information Handling	
			Percent	Hours/Week
Chemistry	8,441	420	38.5	161.7
Hematology	9,562	480	15.4	73.9
Microbiology	8,099	400	21.0	84.0
TOTAL	26,102	1,300	24.6	319.6

[a]Excludes one day's observations when computer was down.

TABLE 8

SUMMARY OF POST-IMPLEMENTATION WORK SAMPLING RESULTS FOR THE CHEMISTRY SECTION TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Activity Measured	Number of Observations	Percent of Total Time Spent	Manhours per Week
1.	Verify and Correct Request Slips	1	0	0
2.	Accession Specimens	854	10.1	42.4
3.	Prepare Worksheets	154	1.8	7.6
4.	Process Test Results	1,758	20.8	87.4
5.	Perform Test Calculations	36	0.4	1.7
6.	Record Test Results	309	3.7	15.5
7.	Transcribe Test Results	89	1.1	4.6
8.	Report Test Results	10	0.1	0.4
9.	Distribute Test Results	2	0	0
10.	File Test Results	34	0.4	1.7
11.	Respond to Inquiries	91	1.1	4.6
12.	Compile Workload Statistics	0	0	0
13.	Log, Calculate and Report Quality Control	107	1.3	5.5
14.	Administrative Handling	15	0.2	0.8
15.	Other--Productive	1,814	21.5	90.3
16.	Other--Nonproductive	170	2.0	8.4
17.	Away from Area	1,450	17.2	72.2
18.	Maintain Computer System	23	0.3	1.3
19.	Accession	904	10.7	44.9
20.	Prepare Worksheets	72	0.9	3.8
21.	Results Entry	472	5.6	23.5
22.	Results Retrieval	33	0.4	1.7
23.	Results Review	32	0.4	1.7
24.	Edit File	11	0.1	0.4
	TOTAL	8,441	100.1	410.4

TABLE 9

SUMMARY OF POST-IMPLEMENTATION WORK SAMPLING RESULTS FOR THE HEMATOLOGY SECTION TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Activity Measured	Number of Observations	Percent of Total Time Spent	Manhours per Week
1.	Verify and Correct Request Slips	0	0	0
2.	Accession Specimens	25	0.3	1.4
3.	Prepare Worksheets	8	0.1	0.5
4.	Process Test Results	2,502	26.2	125.8
5.	Perform Test Calculations	12	0.1	0.5
6.	Record Test Results	9	0.1	0.5
7.	Transcribe Test Results	11	0.1	0.5
8.	Report Test Results	15	0.2	1.0
9.	Distribute Test Results	2	0	0
10.	File Test Results	32	0.3	1.4
11.	Respond to Inquiries	17	0.2	1.0
12.	Compile Workload Statistics	1	0	0
13.	Log, Calculate and Report Quality Control	79	0.8	3.8
14.	Administrative Handling	36	0.4	1.9
15.	Other--Productive	2,123	22.2	106.6
16.	Other--Nonproductive	401	4.2	20.2
17.	Away from Area	3,060	32.0	153.6
18.	Maintain Computer System	67	0.7	3.4
19.	Accession	551	5.8	27.8
20.	Prepare Worksheets	22	0.2	1.0
21.	Results Entry	540	5.6	26.9
22.	Results Retrieval	21	0.2	1.0
23.	Results Review	4	0	0
24.	Edit File	24	0.3	1.4
	TOTAL	9,562	100.0	480.2

TABLE 10

SUMMARY OF POST-IMPLEMENTATION WORK SAMPLING RESULTS FOR THE MICROBIOLOGY SECTION TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Activity Measured	Number of Observations	Percent of Total Time Spent	Manhours per Week
1.	Verify and Correct Request Slips	2	0	0
2.	Accession Specimens	305	3.8	15.2
3.	Prepare Worksheets	15	0.2	0.8
4.	Process Test Results	2,749	33.9	135.6
5.	Perform Test Calculations	6	0.1	0.4
6.	Record Test Results	387	4.8	19.2
7.	Transcribe Test Results	3	0	0
8.	Report Test Results	13	0.2	0.8
9.	Distribute Test Results	10	0.1	0.4
10.	File Test Results	59	0.7	2.8
11.	Respond to Inquiries	34	0.4	1.6
12.	Compile Workload Statistics	--	0	0
13.	Log, Calculate and Report Quality Control	9	0.1	0.4
14.	Administrative Handling	5	0.1	0.4
15.	Other--Productive	1,432	17.7	70.8
16.	Other--Nonproductive	161	2.0	8.0
17.	Away from Area	2,058	25.4	101.6
18.	Maintain Computer System	--	0	0
19.	Accession	502	6.2	24.8
20.	Prepare Worksheets	4	0	0
21.	Results Entry	327	4.0	16.0
22.	Results Retrieval	13	0.2	0.8
23.	Results Review	5	0.1	0.4
24.	Edit File	--	0	0
	TOTAL	8,099	100.0	400.0

handling varied widely among sections: from 15.4 percent in Hematology to 38.5 percent in Chemistry. Based on average day-shift staffing during the post-implementation data collection period of 32.5 (10.5 in Chemistry, 12 in Hematology, and 10 in Microbiology), and assuming 40 hours per week per FTE, or 1300 hours per week total, information handling activities accounted for about 320 hours per week. Approximately 60.5 percent of the time spent on information handling activities, or 194 hours per week, was spent on computer-related activities.

The post-implementation staffing compares with the average staffing of 37 (16, 9, 5, and 11.5) for Chemistry, Hematology and Microbiology estimated for the baseline period, or 35 (14, 9,5, and 11.5) if the two Nuclear Medicine staff are omitted. Thus overall day-shift staffing of the laboratory was reduced by 2.5 FTE, with decreases of 3.5 in Chemistry and 1.5 in Microbiology, and an increase of 2.5 in Hematology. These differences in staffing levels, however, are subject to error because of difficulties in interpretation of the estimates of staffing levels during the baseline sampling period (see Volume II, page 15, of the Baseline Report (3)).

In the Chemistry section, about 17 percent of staff time was spent away from the area, equivalent to 72 hours per week. This time included personal time, time when the laboratory was being cleaned, and time when staff were required to be outside their section. Data collected for the Hematology section indicated that staff were away from the area 32 percent of the time, equivalent to 154 hours per week; as in the baseline period, this large percent of time is attributed partly to the time spent by Hematology staff in assisting in the phlebotomy and reception areas, which are physically near the Hematology Laboratory and under its jurisdiction. Microbiology staff spent about 25 percent of the time away from the area, equivalent to 102 hours per week; a portion of this time was due to staff being required to spend time in the refrigerated media room, which was located on another floor.

Another activity that required a proportionately large percentage of time was the processing of test results. This was evident in all three sections of the laboratory: Microbiology: 33.9 percent, equivalent to 135.6 hours per week; Hematology: 26.2 percent, equivalent to 126 hours per week; Chemistry: 20.8 percent, equivalent to 87.4 hours per week.

4. Comparison of Baseline and Post-Implementation Results

Table 11 compares the time devoted to information handling activities in the baseline and post-implementation periods, in terms of both percent of time and estimated hours per week. The comparisons of percentage of time are considered more accurate than the comparisons of estimated hours per week, due to difficulties in interpretation of the estimates of weekly hours and staffing levels in the three sections during the baseline sampling period. (Baseline hours per week for Chemistry have been adjusted for comparison purposes to reflect the fact that the Nuclear Medicine section was not included in post-implementation sampling; Chemistry staff hours were reduced by 12.5 percent to make the results comparable.)

Overall, the percentage of time devoted to information handling activities was 2.6 percent lower in the post-implementation than in the baseline period; this difference was statistically significant.

Statistically significant (at a 95 percent confidence level) reductions in the percentage of time devoted to information handling activities were observed in Hematology and Microbiology sections (2.7 percent and 1.6 percent, respectively). An increase of 1.2 percent of time devoted to information handling activities was observed for Chemistry. This increase, however, was not statistically significant. The overall reduction in hours per week devoted to information handling between the two study periods was about 60 hours per week. Part of this reduction, however, was due to the difference in staffing. At the staffing level during the post-implementation study, a reduction of 1.6 percent was equivalent to a reduction of 33.8 hours per week devoted to information handling activities, or slightly less than one FTE.

TABLE 11

COMPARISON OF BASELINE AND POST-IMPLEMENTATION INFORMATION HANDLING TIMES
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Percent of Time			Hours per Week		
	Base-line	Post-Implementation	Differ-ence	Base-line	Post-Implementation	Differ-ence
Chemistry	37.3%	38.5%	1.2%	208.6[a]	161.7	-46.9
Hematology	18.1	15.4	-2.7[b]	68.0	73.9	5.9
Microbiology	22.6	21.0	-1.6[b]	103.5	84.0	-19.5
All	27.2[a]	24.6	-2.6[b]	380.1	319.6	-60.5

[a]Adjusted for Nuclear Medicine staff.

[b]Difference is statistically significant at 95% confidence level.

Table 12 compares the percentage of time devoted to several selected activities in the two study periods. Overall, time devoted to processing of test results increased by approximately 1.2 percent. As might be expected, time devoted to transcription and recording of test results was reduced by about 0.9 percent, equivalent to about 16 hours per week. Time devoted to compilation of workload statistics, which accounted for 1.5 percent, or 21 hours per week of time in the baseline period, was eliminated in the post-implementation period because the computer system assumed this function. Time devoted to quality control logging, calculation, and updating was reduced from 2.9 percent to 0.7 percent of total time, or by 31 hours per week.

Time spent away from the area was 25.2 percent in the post-implementation period compared with 32.7 percent in the baseline. It is not clear whether this was due to differences in sampling methodology, or whether the staff did spend more time in the laboratory sections, possibly as a result of reduction in available staff.

5. Conclusion

It is concluded that time devoted to information handling activities in the post-implementation period was approximately 2.6 percent lower than in the baseline. Based on current staffing, this was equivalent to a net reduction of 34 hours per week (day shift, Monday to Friday) devoted to information handling activities in the Chemistry, Hematology and Microbiology sections. As expected, there were reductions in time devoted to transcription and recording of test results, compilation of workload statistics, and for quality control reporting.

C. SERVICE PERFORMANCE

1. Turnaround Time

a. Baseline Results

During the baseline data collection, information was obtained on "process times" within the laboratory; that is, the time between when the request slip was received in the laboratory and the time: (a) the result was telephone back to the requester, in the case of emergent/ urgent requests, or (b) the time the completed slip was placed in the distribution box to be picked up by staff from the wards or clinics, for routine requests.

TABLE 12

COMPARISONS OF BASELINE AND POST-IMPLEMENTATION WORK SAMPLING RESULTS FOR SELECTED ACTIVITIES
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Percent of Time Devoted to Activity								
	Chemistry		Hematology		Microbiology		Total		
	X Period	Y Period	X Period	Y Period	X Period	Y Period	X Period	Y Period	Difference
Process Test Results	19.8%	20.8%	30.1%	26.2%	29.1%	33.9%	25.6%	26.8%	1.2%
Transcribe and Record Test Results	4.3	4.8	3.1	0.2	3.1	0.1	4.0	3.1	-0.9
Compile Workload Statistics	2.9	0	1.9	0	0.4	0	1.5	0	-1.5
Quality Control Reporting	5.8	1.3	1.2	0.8	0.9	0.1	2.9	0.7	-2.2
Away From Area	25.9	17.2	41.2	32.0	33.8	25.4	32.7	25.2	-7.5
	Hours per Week Devoted to Activity								
Process Test Results	110.7[a]	87.4	113.7	125.8	133.4	135.6	357.8	348.8	9.0
Transcribe and Record Test Results	23.2	20.1	14.7	1.0	18.5	19.2	56.4	40.3	-16.1
Compile Workload Statistics	16.1[a]	0	3.3	0	1.6	0	21.0	0	-21.0
Quality Control Reporting	32.4[a]	5.5	4.4	3.8	4.0	0.4	40.8	9.7	-31.1
Away From Area	145.0[a]	72.2	155.9	153.6	155.1	101.6	456.0	327.4	-128.6

[a]Adjusted for Nuclear Medicine staff.

The raw data obtained during the baseline data collection were reviewed. Some of the data was unusable due to lack of identification of data sheets, obvious errors (e.g., receipt dates being later than dates of results report), and errors in the calculation of process times. After errors were corrected, questionable data eliminated and data points excluded that were more than six standard deviations from the mean, a total of 412 usable observations remained for analysis. The results are summarized in Table 13. The majority of the observations (250) were made for routine results for Hematology tests, with the remainder made for routine Chemistry, STAT Chemistry, STAT Hematology, and Microbiology tests.

In the case of both Chemistry and Hematology STAT requests, results were phoned back to the requester an average of 1.25 hours after receipt of the slip by the laboratory (SD=0.7 hours). Routine Chemistry results were available in the distribution box an average of 16 hours after receipt by the laboratory, whereas routine Hematology results were available an average of 4.7 hours after receipt. The average for availability of Microbiology results was 39 hours after receipt. The distribution of process turnaround times was quite broad for the Chemistry and Hematology routine results, with a coefficient of variation (standard deviation/mean) greater than 1, whereas the distributions for STAT results and for Microbiology results were much narrower, with a coefficient of variation of 0.55 or less.

b. Post-Implementation Results

Because of major differences in the way results were returned from the laboratory to the clinics and wards in the post-implementation period, the method by which the process times were measured was different:

STAT Turnaround Time. The TRILAB computer system recorded both the time (date and time of day) "received" (the accession time), and the time that the result was verified and transmitted to the requesting ward or clinic (a "beep" was produced at the appropriate clinic or ward when the result was available). Consequently these times were obtained via terminal look-up of appropriate test records.

TABLE 13

BASELINE PROCESS TURNAROUND TIMES
FOR SELECTED TESTS
IN THE CLINICAL LABORATORY AT NRMC OAKLAND

Test Type	Sample Size N	Sample Size N[a]	Mean (Hours)	S.D. (Hours)	Coefficient of Variance ($\sigma/\bar{x}$)
Chemistry Routine	52	51	16.10	18.56	1.15
Hematology Routine	254	250	4.70	4.91	1.03
Chemistry STAT	39	33	1.27	.70	.55
Hematology STAT	64	62	1.25	.67	.53
Microbiology	16	16	39.10	13.91	.35

[a]After deleting thirteen observations greater than $\pm$ 6 times the standard deviation from the mean.

Routine Results Turnaround Time. The time that routine results were available to requesters via terminal inquiry was similarly determined, using terminal look-up.

Interim Report Results Turnaround Time. The times that the interim reports were available was obtained by copying the print end times for those requisition in the sample for which interim reports are produced. These include only the inpatient floors with surgical patients (fourth floor, 6 East, 6 West, 6 North, 7 East, 7 West, 7 North, 8 East, 8 West, and 8 South). Thus those requisitions for which an interim report time was available constituted a subset of the original samples.

Daily Summary Reports Process Time. A similar procedure was followed to obtain the print end times for the daily summary reports.

Report Pickup Time. The time that the daily reports were picked up for distribution to wards and clinics was obtained from the logs kept in the data processing department.

Table 14 summarizes the sample sizes and averages, medians, and standard deviations of the process times obtained. Five process times are shown:

(1) CRT Process Time (first results available): the elapsed time between accessioning of a request by the laboratory department and availability of the first results via terminal.

(2) CRT Process Time (final results available): the time between accessioning of the requisition and availability of all test results via terminal inquiry.

(3) Interim Report Process Time: the time between requisition accessioning and availability of the "daily interim hard-copy report" for pickup in the Data Processing Department.

(4) Daily Report Process Time: the time between accessioning and availability of the daily reports for pickup by clinic/ward personnel.

(5) Final Report Pickup Time: the time between accessioning and the time the daily report was picked up.

TABLE 14

POST-IMPLEMENTATION PROCESS TIMES FOR LABORATORY TESTS
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND[a]

Test Type	CRT Process Time (First Results Available)			CRT Process Time (Final Results Available)		Interim Report Process Time			Daily Report Process Time		Final Report Pickup Time	
	Sample Size N[b]	Average	Standard Deviation	Average	Standard Deviation	Sample Size	Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
STAT/Urgent												
Chemistry	48	1.50	1.14	3.50	4.92	26	9.6	4.1	17.7	6.1	23.8	18.4
Hematology	92	0.85	.65	2.17	1.33	57	10.3	4.7	17.9	5.8	21.2	11.4
Routine												
Chemistry	100	23.1	31.7	24.4	31.2	45	22.0	12.1	39.4	34.8	54.3	46.2
Hematology	218	1.14	0.75	2.12	1.40	108	9.5	4.9	16.4	5.7	25.8	23.5
Microbiology	35	23.7	21.4	59.6	26.6	10	64.1	22.7	73.6	27.1	94.1	38.8

[a] All times in hours.

[b] Samples have been adjusted to exclude ± 4 times the standard deviation (reduced Chemistry STAT tests by 2 and Hematology STAT and routine tests by 1).

A total of 493 observations was obtained (after excluding outlier data points more than four standard deviations from the mean). The number of observations of each test category was chosen to be consistent with the sample size and variability of observations in the baseline period. As in the baseline period, Hematology routine observations constituted the largest subsample, with the remainder for routine Chemistry, STAT/urgent Hematology, STAT/urgent Chemistry, and Microbiology tests.

In the case of STAT/urgent tests, first results were available on average 1.5 hours after accessioning for Chemistry tests, and 0.85 hours after accessioning for Hematology tests. Final results (which generally included non-STAT/urgent tests on the requisition) were available via CRT inquiry 3.5 hours after requisition for Chemistry, and 2.2 hours for Hematology.

In the case of the routine request requisitions, results were available for Chemistry tests on average 24 hours after accessioning, 2 hours for Hematology tests, and 60 hours for Microbiology tests.

Interim reports were available (for patients on surgical floors) approximately 10 hours after accessioning for Chemistry and Hematology STAT/urgent tests, 22 hours for Chemistry routine tests, 9.5 hours for Hematology routine tests, and 64 hours for Microbiology tests. The daily reports were available approximately 18 hours after accessioning for Chemistry and Hematology STAT/urgent tests, 39 hours for Chemistry routine tests, 16 hours for Hematology routine tests, and 74 hours for Microbiology tests. The average pickup time for the reports was 21-24 hours for Hematology and Chemistry STAT/urgent tests, 54 hours for Chemistry routine tests, 26 hours for Hematology routine tests, and 94 hours for Microbiology tests.

The distribution of "CRT process times" for routine Chemistry tests was quite broad, with a coefficient of variation (standard deviation/mean) of about 1.4, whereas the distributions for the other test type categories were much narrower, with coefficients of variation of 0.9 or less.

c. Comparison of Baseline and Post-Implementation Laboratory Process Times

Table 15 compares process times observed in the two study periods. In the case of the STAT/urgent tests, the post-implementation averages presented are for the "CRT process time" (first results available), as being most comparable to the process time measured in the baseline period (time when results were telephoned back to the requesting units). In the case of routine tests, the final results available via CRT are presented, as being most comparable to process times measured in the baseline period (completed results slips available for pickup).

The results suggest that process times were reduced in the post-implementation period compared to the baseline period for Hematology STAT/urgent test (by 0.4 hours) and for Hematology routine tests (by 2.6 hours); these differences were statistically significant at the 95 percent confidence level. The process times for STAT/urgent and routine Chemistry tests increased (by 0.23 hours and 8.3 hours, respectively); these differences, however, were not statistically significant. Average process times for Microbiology tests increased by about 20 hours; this difference was statistically significant.

The differences observed must be interpreted with caution for the following reasons:

- In the case of routine tests, the process times are not entirely comparable because in the baseline period the process time represents the time when the requisition slip was available for pickup, where the post-implementation process time represents the time that the result was in fact available to the requester (via terminal look-up). The time between availability of the completed requisition slip and pickup or availability of the result to the requester was not measured in the baseline study at

TABLE 15

COMPARISON OF BASELINE AND POST-IMPLEMENTATION AVERAGE PROCESS TIMES
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Mean Turnaround Time (hours)			
STAT/Urgent	Baseline	Post-Implementation	Difference	F Test
Chemistry	1.27[a]	1.50[b]	0.23	2.6*
Hematology	1.25[a]	.85[b]	-0.40*	1.07
Routine				
Chemistry	16.1[c]	24.4[d]	8.3	2.8*
Hematology	4.7[c]	2.1[d]	-2.6*	12.3*
Microbiology	39.1[c]	59.6[d]	20.5*	3.5*

[a]Time from receipt of specimen by laboratory to telephoning results.
[b]Time from accessioning to availability of first results via terminal.
[c]Time from receipt of specimen to availability of results at distribution box.
[d]Time from accessioning to availability of final results via terminal.
*Statistically significant difference at 95% confidence level.

NRMC Oakland. At DDEAMC,* however, total turnaround time was measured in addition to "process time;" the difference varied between 17 hours and 20 hours, on average. Thus routine results were available to the provider (via terminal inquiry) considerably sooner in the post-implementation period for routine Chemistry and Hematology tests, and probably in about the same time for Microbiology tests.

- During the post-implementation period, the tests to be sampled in each test type category were chosen by using an appropriate "skip" interval between tests, in order to obtain a random sample representative of turnaround times. It is not clear how the sample for the baseline period data collection was chosen; as indicated in the baseline report, much of the data was unusable due to lack of identification of data sheets, obvious errors (e.g., receipt dates being later than dates of results report) and errors in the calculation of process times, resulting in some questionable data. In fact, there is evidence that the distributions (spreads) of test result process times are not the same in the two periods, as measured by the statistical F Test. As indicated in Table 15 the distribution of test results in the two study periods are significantly different for each test category, except for Hematology STAT/urgent tests.
- Operating conditions in the laboratory were not the same in the two study periods. The Hematology Laboratory had obtained a new Coulter S+ instrument, which had a higher throughput rate than the previous instrument (the Coulter

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*A mini baseline evaluation was conducted to evaluate TRILAB at Eisenhower AMC. Complete results are summarized in the baseline report, Volume III (3).

was the major instrument utilized in the Hematology section). Staffing in the Chemistry section, as mentioned earlier, was somewhat reduced from that of the baseline period. Also, staff were preparing for the Joint Accreditation visit, which may have resulted in fewer staff being available for production of tests.

- The apparent increase in Microbiology test times is difficult to explain, except for the possibility that the smaller baseline sample (16 observations) may not be representative of the tests carried out in the Microbiology section (specific tests and requesting locations were not provided in the baseline data); as mentioned above, the distributions of process times were significantly different. Since test times in Microbiology are longer and vary so much, depending on type of specimen and results (positive or negative), differences in the type of tests sampled in the baseline and post-implementation periods could result in considerably different test times, which masked any differences in reporting times.

d. Conclusions

Given the above qualifications, the following conclusions may be drawn:

(1) For STAT/urgent tests, process times--times between receipt of requisition and transmission of test results to provider locations (via telephone in the baseline period and via terminal in the post-implementation period)--were either unchanged (Chemistry) or reduced (Hematology).

(2) For routine tests, results were <u>available</u> to provider locations (via terminal) sooner in the post-implementation period than in the baseline period for Chemistry and Hematology, and in about the same time period or sooner for Microbiology. Hard-copy daily reports were generally available to providers later than the completed results

requisition slips were in the baseline period. Interim hard-copy reports (for the surgical floors) were available sooner in the post-implementation period for Hematology tests, and in approximately the same time for Chemistry and Microbiology tests.

2. Number of Telephone Calls

a. Baseline Results

The number of telephone calls received by the laboratory was monitored over a period of seven days during the day shift, Monday through Friday in the baseline study. Calls were categorized as:

(1) request for results on file;

(2) request for information on other results;

(3) request for the supervisor;

(4) request for technician; or

(5) request for general information.

Table 16 summarizes the number of calls received, by type of call. A total of 724 calls were received during the total observations period of 2,879 minutes, equivalent to 724 x 480/2,879 or about 102 calls received per (8-hour) day. Based on the 147,625 patient tests reported performed during October of 1980, the average daily test load was 4,762 tests per day for the 31 day period. Assuming the number of telephone calls to the laboratory was similar on weekdays and weekends, this represented an average of one call for every 46.5 tests performed. Sixty percent of the calls were requesting information from the laboratory with regard to test results; an additional 12 percent of calls were for filed results.

b. Post-Implementation Results

The number of telephone calls received by the laboratory was monitored over a period of 10 days during the post-implementation study. These data were collected during the day shift, Monday through Friday, during the period October 8-22, 1982. The monitoring procedures utilized were similar to those in the baseline period. As in the baseline period, calls were categorized as:

TABLE 16

COMPARISON OF BASELINE AND POST-IMPLEMENTATION PERIOD TELEPHONE CALL RESULTS
TRILAB EVALUATION IN THE CLINICAL LABORATORY AT NRMC OAKLAND

	Number per Eight-Hour Day		Ratio of Baseline to Post-Implementation	
Type of Call	Baseline	Post-Implementation	Unnormalized	Normalized for Workload
For filed results	12.5	2.9	0.23	0.20
Information from laboratory	62.4	34.4	0.55	0.48
Supervisor	12.9	8.8	0.68	0.59
Technician	9.0	17.8	1.98	1.72
General Information	5.6	3.5	0.63	0.55
TOTAL	102.4	67.4	0.66	0.57

(1) calls requesting information from filed results;

(2) calls requesting information from the laboratory;

(3) calls for a specific supervisor;

(4) calls for a technician, and

(5) calls for general information.

Table 16 provides a comparison of the number of calls per day received by the laboratory during the two study periods. In the post-implementation period study, the laboratory received an average of 67.4 calls per day. The total number of calls received per day during the post-implementation period was, therefore, two-thirds that received during the baseline period. The distribution of calls by type was similar to that received during the baseline period, with the majority of calls (51 percent) requesting information from the laboratory with regard to test results. The number of calls received was lower in each category of call request, except for calls to technicians, which doubled from 9 calls per day during the baseline period to about 18 calls per day during the post-implementation period. The reason for the increase in calls in this category is not known.

Based on the 170,150 patient tests reported performed during October 1982, the average daily test load was 5,489 tests per day for the 31-day period. Assuming the number of telephone calls to the laboratory was similar on weekdays and weekends, this represented an average of one call for every 81.4 tests performed. This was a reduction of 43 percent from the average of 1 call for every 46.5 tests measured during the baseline period.

It should be noted that not all nursing stations or clinics had terminals and not all areas of the laboratory (viz., Nuclear Medicine, Pathology and Blood Bank) were on the system. When the remaining areas are put on the system, and if additional terminals are obtained for provider areas, the volume of telephone calls could be expected to be further reduced.

c. Conclusions

The volume of telephone calls to the laboratory was considerably reduced by implementation of the TRILAB system. Normalized to study period workloads, the volume of telephone calls in the post-implementation period was almost half (57 percent) that in the baseline study period.

D. STAFF PERCEPTIONS OF LABORATORY SERVICES

1. Baseline Survey

a. Introduction

Study questionnaires were distributed to the following groups of personnel at the hospital during the baseline survey:

	No. Sent	No. Returned	Response Rate
1. All medical staff (MDs and dentists)	276	183	66.2%
2. All nurses	243	146	60.1
3. Administrative, corpsmen and clerical staff	103	57	55.4
4. Laboratory staff	73	63	83.3
	695	449	64.3

The purpose of the questionnaires was to determine the degree of satisfaction of various providers and staff with regard to their perceptions of laboratory operations. The questionnaire included 19 questions regarding the respondent's perception of the clinical laboratory operations at NRMC Oakland, and about the interaction and communication that takes place between the laboratory and medical staff. Questions were included with regard to perceptions about such factors as:

- relations with laboratory personnel;
- legibility, quality, accuracy and format of laboratory reports;
- amount of time required to obtain test results;
- promptness and completeness of laboratory reports in patient records; and
- ease of and amount of time required to obtain information by telephone.

Respondents were asked to rate satisfaction with each factor. These ratings, assigned scale values of 5, 4, 3, 2, 1 (the conventional Likert scale) were:

5 highly satisfactory;

4 satisfactory;

3 neither satisfactory nor unsatisfactory;

2 unsatisfactory; or

1 highly unsatisfactory.

In addition, a number of questions were included inquiring about respondent's position, medical specialty, and years at NRMC Oakland. A summary of the responses by physicians, nurses and physicians' assistants, and administrative staff, is presented in Table 17.

b. Medical Staff

A total of 183 questionnaires were returned (66.2 percent response rate). Of those physicians responding, the internal medicine specialty composed the largest group (13 percent). The second largest group was surgery (12 percent), followed by pediatrics (10 percent). Approximately 38 percent of physicians had been at the facility between one and three years and 24 percent were assigned for less than one year. All responding physicians were military officers.

In terms of usage, 12 percent felt that their use in requesting tests was heavy. The majority (48 percent) felt that their use was average, and 39 percent felt that it was light. Sixty-three percent of the respondents indicated that within the last month they had patient laboratory tests lost. This happened two or fewer times per month according to the majority (66 percent) of physicians.

In the specific question areas addressed, physicians indicated concern for the following:

- the promptness with which laboratory reports are filed in patient charts (mean weighted scale rating of 2.57);
- the completeness with which laboratory reports are filed in patient charts (2.73);
- the frequency with which laboratory results are lost (2.71);
- the amount of time required, once they reach the laboratory by telephone, to obtain information about a specific patient or result (2.62).

TABLE 17

WEIGHTED MEAN SATISFACTION LEVELS AT NRMC OAKLAND[a]
REGARDING CLINICAL LABORATORY SERVICES
BASELINE STUDY

	Physicians	Nurses and Physicians Assistants	Other Users (Administrative)
Accuracy of results provided by Lab	4.0	3.4	NDA[b]
Completeness of Lab reports	3.9	3.4	3.1
Length of time between routine tests and results	3.2	2.7	NDA
Length of time between STAT tests and results	2.8	2.8	NDA
Overall laboratory performance	3.6	3.4	3.8

[a]Weighted mean response was obtained by assigning values of 1 through 5 to the categories of "not at all satisfied" through "very satisfied," respectively, and dividing the sum by the number of responses.

[b]No Data Available (NDA).

On the other hand, physicians tended to be satisfied with the following:

- legibility of laboratory reports (3.92);
- quality of information contained in laboratory reports (3.88);
- format in which information is presented in laboratory reports (3.73)
- accuracy of the information received from the laboratory (3.74);
- contribution of the clinical laboratory to patient care (3.91);
- confidence in the information received from the laboratory (3.85).

c. Nursing Staff

The nursing questionnaire was similar in format to the physician questionnaire. A total of 146 questionnaires were returned, representing a response rate of 60.1 percent. Approximately 80 percent were from RNs and 17 percent from LPNs. The sample consisted of 67 percent military officers and 31 percent civilian nurses. The majority considered themselves average (49 percent) or above average (33 percent) users of the laboratory services. Fourteen percent considered themselves below average users. Similar to the physician responses, most (59 percent) nurses felt that laboratory tests had been lost in the past month, although most (60 percent) indicated this happened two or fewer times per month.

Interestingly, no major differences were noted in response ratings between nurses and physicians. Slight differences noted include:

- Nurses felt that the "promptness with which laboratory reports are filed in patient charts" was somewhat satisfactory (average scale rating 3.24), while physicians felt it was somewhat unsatisfactory (2.57).
- Similarly, for "the completeness with which laboratory reports are filed in patient charts" was somewhat satisfactory (average scale rating 3.24), while physicians felt it was somewhat unsatisfactory (2.57).

- Also, physicians were somewhat more satisfied with the confidence in the information received from the laboratory (3.85) than nurses (3.37).

d. Laboratory Staff

A separate survey questionnaire was administered to 73 civilian and enlisted personnel on the laboratory staff. The response rate was 86.3 percent. Ten out of the 30 questions in the baseline laboratory personnel questionnaire which might be affected by an automated laboratory system were analyzed:

- I have enough time to get the job done (1);
- I have enough space to work effectively (2);
- The work is interesting (6);
- I have enough information to get the job done (12);
- I have enough equipment to get the job done (13);
- My supervisor is competent in doing his/her job (15);
- My responsibilities are clearly defined (17);
- The pay is good (25);
- The chances for promotion are good (25);
- On the whole, I am quite satisfied with my job (30).

The remaining questions dealt with the overall satisfaction with issues such as ability to make friends, time to get to work, etc.--issues judged to be less affected by TRILAB. For questions 1, 12, 13, 17, the respondents "tend to agree" and "definitely agree" that they had enough time, information, and equipment to get their work done, and that their responsibilities were clearly defined (mean composite scores of 3.61, 4.05, 3.89, 3.71, respectively). Interestingly, 19 percent believed that they did not have the time necessary to do their job. A majority of the respondents (60 percent) "tend to agree" that they "are quite satisfied" with their job; however, 40 percent of the respondents were either uncertain or dissatisfied with their job.

Although only 60 percent were satisfied with their job, 88 percent agreed that the work was interesting (question 6). Questions 25 and 29 attempted to examine the issues of pay and promotions. The

data showed that 43 percent definitely agreed the pay was low. A total of 70 percent either agreed that pay was low or were uncertain. Similarly, 75 percent either disagreed with or felt uncertain about the chances of promotion.

2. Post-Implementation Study

Survey questionnaires were also distributed to all medical staff, nurses, administrative corpsmen and clerical staff, and laboratory staff in the hospital during the post-implementation study. The purpose of the questionnaires was to determine the degree of satisfaction of various provider categories and staff with regard to TRILAB operations and to compare their perceptions of operations of the clinical laboratory with TRILAB, compared with manual (baseline) operations prior to implementation of the TRILAB system.

The questionnaire included some 20 questions regarding the respondents' perception of various specific aspects of the TRILAB system. Respondents were asked to rate satisfaction with each factor. These ratings, assigned scale values of 5, 4, 3, 2, 1 (the Likert scale) were: 5--highly satisfactory; 4--satisfactory; 3--neither satisfactory nor unsatisfactory, or undecided no/opinion; 2--unsatisfactory; or 1--highly unsatisfactory.

In addition, a number of questions were included inquiring about respondents' overall satisfaction with clinical laboratory services and with the TRILAB system; frequency of occurrence of problems; and frequency of problems compared to previous manual laboratory operations (to be answered by those staff who were also at the facility before TRILAB was installed).

The number of questionnaires distributed and the responses are summarized below:

	Number Sent	Number Returned and Utilized	Response Rate
All medical staff (MDs and dentists)	258	91	35.3%
Nursing staff, including physicians' assistants	250	87	34.8
Administrative, corpsmen	100	60	60.0
Laboratory staff	100	39	39.0
Overall	708	277	39.1%

The overall 39 percent response rate of usable (completed) questionnaires was less than that achieved in the baseline period (64 percent), primarily because many potential respondents (such as dentists, psychiatrists, pharmacists, etc.) had no familiarity with or did not use the TRILAB system; a number of uncompleted questionnaires were returned with such comments.

Of the medical staff responding to the questionnaire, 43 percent described themselves as "light" users of the clinical laboratory, 25 percent "moderate" users and 11 percent "heavy" users. Of the nursing staff responding, 18 percent described themselves as "light" users, 36 percent "moderate" users and 45 percent "heavy" users. Eighty-three percent of the administrative staff indicated that they were "light" users, 17 percent "moderate" users and none indicated that they were "heavy" users.

b. Questionnaire Results: Users Satisfaction Levels. A copy of the questionnaire sent to physicians, nurses and physicians' assistants and other administrative users (corpsmen and clerks), and a detailed analysis of selected responses are presented in Appendix A. A summary of the results is presented in this section.

Table 18 summarizes the weighted mean satisfaction levels with regard to various aspects of the TRILAB system for physicians, nurses and physicians' assistants, and other users. In general, users tended to be satisfied with aspects of the TRILAB system such as system availability, system reliability, and system accuracy. Users were also satisfied with regard to clarity, completeness and abnormals' identification in the reports (average scale reading of approximately 4.2) and somewhat less satisfied with conciseness of the report format (4.0).

Users were moderately satisfied with system efficiency, as measured by result turnaround times and training (3.0-3.5), and were quite satisfied with results accuracy (4.0). Users were also reasonably satisfied with various aspects of information retrieval, such as access to laboratory results, retrieval of previous data, ease and timeliness of results retrieval (3.5-4.1). Access to STAT paper-copy results received a somewhat lower rating (3.1).

TABLE 18

WEIGHTED MEAN SATISFACTION LEVELS OF USERS
REGARDING TRILAB SYSTEM AT
NRMC OAKLAND

System Aspect	Mean Satisfaction Level[a]		
	Physicians	Nurses and Physician Assistants	Other Users (administrative)
A. TRILAB System			
System Availability	3.7	4.0	4.2
System Reliability	3.8	3.9	3.9
System Accuracy	4.3	4.2	4.1
B. Test Report Form			
Clarity of Printout	4.5	4.6	4.4
Completeness of Results	4.2	4.2	4.1
Abnormals Indication	4.3	4.5	4.3
Conciseness	3.6	4.1	4.2
C. System Efficiency			
STAT Inpatient Turnaround Time	3.3	3.0	3.4
Routine Inpatient Turnaround Time	3.6	3.5	3.3
STAT ER Turnaround Time	3.4	3.0	3.5
Routine Outpatient Turnaround Time	3.3	3.3	3.5
Special Case Flexibility	3.5	3.2	3.5
Training	3.3	3.1	3.3
D. Results Accuracy	4.1	4.0	4.1
E. Information Storage and Retrieval			
Access to Laboratory Results	3.9	4.1	4.1
Access to STAT Reports	2.8	3.1	3.3
Retrieval of Previous Data	3.4	4.0	3.9
Cumulative Results	3.5	4.1	4.0
Searching Patient Data Base	3.2	3.7	3.6
Ease and Timeliness	3.7	3.5	3.6
F. Overall Satisfaction			
With Laboratory Services	3.7	3.5	3.6
With TRILAB	3.9	3.7	3.9

[a] Average of Likert scale values.

Overall, users provided an average satisfaction rating of 3.6 with laboratory services and 3.8 with the TRILAB system. No consistent or major differences were noted in response ratings among physicians, nurses and other users.

Frequency of Problem Occurrences. Table 19 summarizes the users' perceived frequency of problems with laboratory services in the post-implementation period. Survey responses were calculated in terms of occurring often, occasionally, rarely or no opinion. (Information similar to this was not collected in the baseline survey.) Excluding "not applicable" and "no opinion" responses, the median response was "occasionally" for:

- tests repeated due to delay in receiving original results;
- tests repeated due to lost results;
- tests repeated due to inaccurate results;
- frequency of phone calls to obtain results; and
- duplication of report data.

A number of comments with regard to report format were made in the comments section (see below).

Comparison of TRILAB with Manual Operations. Users were asked to compare relative frequency of problem events under TRILAB operations with previous laboratory (manual) operations. Only those users who were at the facility before TRILAB was installed (in February 1982) were asked to answer this question. Two-thirds of the respondents to the post-implementation survey fell into this category.

The TRILAB system received relatively "high marks" for most problem categories (Table 20). The median response was that the following occurred "less frequently" with the TRILAB system:

- tests repeated due to delays (43.4 percent felt they occurred less frequently);
- tests repeated due to lost results (46.7 percent); and
- telephone calls to the laboratory (64.6 percent).

The median response to "tests repeated due to inaccurate results" was that this occurred with similar frequency (40.3 percent). Unnecessary duplication of report data also received a median response of "similar frequency with TRILAB;" as mentioned above, a number of written comments were made on report format.

TABLE 19

FREQUENCY OF EVENTS RELATING TO LABORATORY TEST RESULT AVAILABILITY AS REPORTED IN POST-IMPLEMENTATION SURVEY OF USERS AT NRMC OAKLAND

Event	Frequency (Percent of Respondents)			
	Often	Occasionally	Rarely	No Opinion
Tests repeated due to delays	5.6%	36.4%	27.9%	21.5%
Tests repeated due to lost results	3.9	41.9	28.4	16.2
Tests repeated due to inaccurate results	5.2	38.6	29.6	17.6
Telephone calls to laboratory	18.5	46.4	21.0	9.4
Duplication of report data	35.1	20.3	15.6	20.8

TABLE 20

COMPARISON OF TRIBAB WITH MANUAL OPERATIONS
POST-IMPLEMENTATION PERIOD OF USERS
NRMC OAKLAND*

	Change in Frequency (Percent of Respondents)				
	More Frequently With TRILAB	Similar Frequency	Less Frequently	Never with TRILAB	No Opinion
Tests repeated due to delays	9.3%	23.1%	43.4%	1.6%	22.5%
Tests repeated due to lost results	6.0	24.7	46.7	2.7	19.8
Tests repeated due to inaccurate results	0.6	40.3	29.3	2.2	27.6
Telephone calls to Laboratory	6.1	14.4	64.6	2.2	12.7
Unnecessary duplication of report data	35.7	13.2	24.2	2.2	24.7

*Completed by users who were also at the hospital prior to installation of TRILAB.

Utilization of TRILAB Inquiry Capabilities. Users were asked to indicate relative frequency of utilization of the inquiry capability of the TRILAB system (Table 21). Physicians indicated that they used the system "often" to obtain results performed the previous day and within two to six days and "occasionally" for results performed within one or more weeks. Nursing staff and other users indicated that they "occasionally" utilized the system to retrieve results carried out the previous day and within two to six days, and "rarely" for results performed over a week ago.

Acceptable Turnaround Times. Users were asked to indicate acceptable turnaround times for categories of tests results (Table 22 and Figure 3). Physicians indicated on the average they desired that STAT inpatient test results be received within 0.75 hours and that STAT requests from the Emergency Room be received within 0.54 hours. Acceptable average turnaround times for routine inpatient tests were 14.3 hours and for routine outpatient tests 30.3 hours. Nurses and other users had somewhat lower acceptable turnaround times.

Comments. In addition to answering the specific questions, respondents were asked to provide any additional comments on the TRILAB system. Approximately 60 physicians, or two-thirds of physician respondents, provided such additional comments. Most of the comments referred to ways in which the effectiveness or usefulness of the system could be improved, from the physicians' point of view. The most frequent comments, in descending order of frequency, were:

- Need for More Terminals. The most frequent comment made (21 respondents) was for the need for more terminals, particularly in areas such as Urology, and the Dental, ENT and Pediatric Clinics, which did not have TRILAB terminals.
- Format of Computer Printout The next most frequent comment (14 respondents) was that the computer printouts were too large and redundant. For example, it was felt that it was not useful to include pending results on the reports, and that a whole sheet of paper was not necessary to provide a single result.

TABLE 21

FREQUENCY OF TRILAB INQUIRY TO OBTAIN TEST RESULTS
POST-IMPLEMENTION SURVEY AT NRMC OAKLAND

Time Period When Patient Test Was Performed	Median Response		
	Physicians	Nurses Physician Assistants	(Other Users (administrators)
Previous Day	Often	Occasionally	Occasionally
Previous 2-6 Days	Often	Occasionally	Occasionally
Previous 1-2 Weeks	Occasionally	Rarely	Rarely
Over 2 Weeks Previously	Occasionally	Rarely	Rarely

TABLE 22

ACCEPTABLE TURNAROUND TIMES
POST-IMPLEMENTATION PERIOD SURVEY AT NRMC OAKLAND

Test Type	Acceptable Mean Turnaround Time (hours)		
	Physicians	Nurses, Physician Assistants	Other Users (administrative)
STAT Inpatient	0.75	0.57	0.57
Routine Inpatient	14,30	11.20	10.90
STAT ER	0.54	0.35	0.30
Routine Outpatient	30.30	20.90	30.00

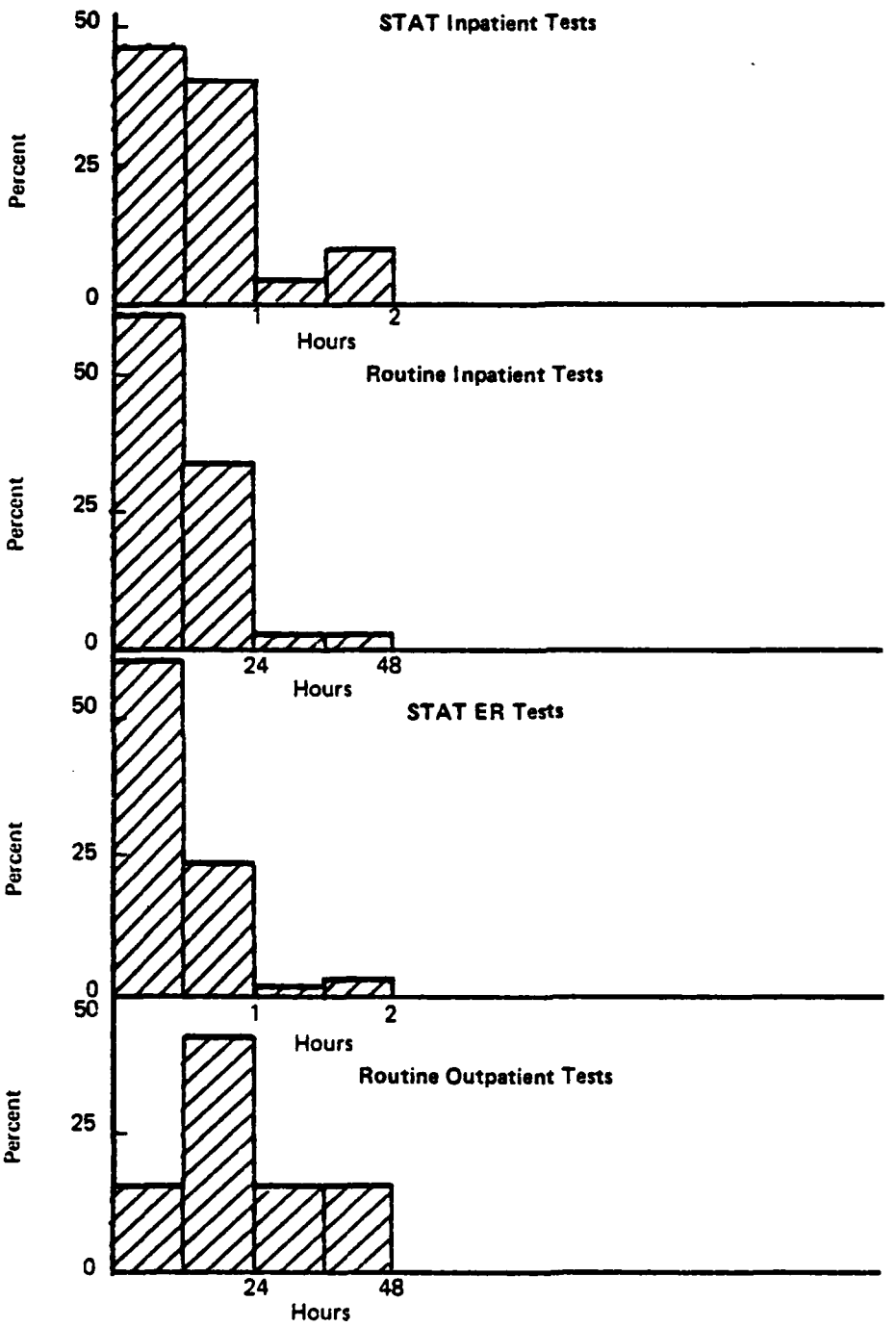

FIGURE 3 ACCEPTABLE TEST TURNAROUND TIMES
POST-IMPLEMENTATION SURVEY AT NRMC OAKLAND

- Need for Nuclear Medicine Results. Six respondents felt that the addition of the Nuclear Medicine laboratory results on the system was very important.
- Patient Address/Telephone Number. It was felt by six respondents (clinic physicians) that it would be very useful to have patients' telephone numbers and addresses on the printout, so that the patient could be notified more easily, e.g., if results were abnormal.
- Delay in Getting Hard-Copy. Six respondents felt that STAT turnaround time for the hard-copy results was too long.
- STAT Turnaround Time Too Long. Three respondents felt that STAT results turnaround time was too long.
- Formal Training. Four respondents expressed the need for a better training program on utilization of the terminals and for an instruction manual.
- System Nonfunctioning. Three physician respondents commented on the fact that the system was down too frequently.
- Inadequate Memory. Three respondents commented on the insufficient archival capacity of the system for results.

Approximately 50, or 60 percent, of the nursing staff questionnaires had comments with respect to the TRILAB system operations. Several of the comments indicated that the system had improved service from the laboratory, citing the fact that there were fewer telephone calls required to obtain results and a resultant reduction in staff workload. However, most of the comments dealt with areas in which service could be improved:

- Multiple Terminal Beeps. Twelve of the questionnaires mentioned the fact that their terminal "beeped" unnecessarily, taking staff away from their regular duties. It was felt by three respondents that beeping for incomplete results was inappropriate; they needed complete laboratory results before being able to take any action. The system

too frequently beeped for STAT results which had already been received, or when results were being "dumped" (cleared from the system); that is, there appeared to be hardware or software problems which resulted in unnecessary beeps.

- More Terminals. The second most frequent comment (nine respondents) expressed the need for terminals in areas (such as the operating room), which did not have terminals.
- STAT/Urgent Turnaround Times. Five respondents commented that the turnaround time for STAT/urgent requests was frequently too long.
- Matching of Results with Patient Records. Five staff commented on the fact that laboratory results often were filed under an incorrect patient record, e.g., the incorrect admission for a patient who had had multiple admissions to the facility. This increased the time required to find the result.
- Training. Four respondents commented on the lack of adequate training received by ward staff, and an additional two commented on the fact that there were no operating instructions provided for use of the terminals.
- Interim Report Turnaround Time. Three respondents commented that frequently the interim reports for pre-operative patients were not available on time.

Twenty-three of the questionnaires by corpsmen, clerks and hospital technicians, or about 40 percent of the questionnaires in this category, had comments with regard to the operation of the TRILAB system:

- Report Redundancy. Five respondents felt that the reports produced by the system were frequently superfluous or redundant, reporting the same test result.
- Multiple Beeps. Four of the respondents commented on the multiple beep problem of the terminals.

- Training. Three corpsmen pointed out that the corpsmen had received either insufficient or no training in utilization of the system.

The comments received by and large mirrored those of the nursing staff.

c. Questionnaire Results: Laboratory Staff

A separate survey questionnaire was administered to the personnel on the laboratory staff. A copy of the questionnaire and detailed analysis of survey results are presented in Appendix A.

Satisfaction Ratings. Laboratory staff were asked to indicate their satisfaction rating with regard to a number of characteristics of the TRILAB system. The results are summarized in Table 23. On average, laboratory staff did not assign as high a satisfaction rating to the TRILAB system as did users. In particular, only average satisfaction was expressed with regard to system availability, reliability, ease of order entry, results entry, and logging functions (scale ratings of 2.5-2.9). Somewhat higher satisfaction levels were expressed with regard to system accuracy, clarity of printout, inquiry capability, file edit capability, and abnormals identification (ratings of 3.1-4.1).

Training and perceptions of medical staff familiarity with the system received lower scale ratings (2.8). Screen legibility was considered very satisfactory (4.5), but command functions and terminal locations received lower ratings (3.3 and 2.7).

Moderate satisfaction was expressed with regard to information storage and retrieval, quality control data and quality control reporting (2.8-3.4).

Overall satisfaction with the TRILAB system was neutral (2.4), but above average satisfaction was reported for overall laboratory services (3.6).

Frequency of Problems. With regard to frequency of problem occurrences (Table 24), most respondents indicated that:

- repeating of tests due to lost results occurred only occasionally (42 percent) or rarely (42 percent);

TABLE 23

WEIGHTED MEAN SATISFACTION LEVELS BY LABORATORY PERSONNEL
REGARDING TRILAB SYSTEM
NRMC OAKLAND

System Aspect	Weighted Mean Scale Rating[a]
A. TRILAB System	
System Availability	2.8
System Reliability	2.7
System Accuracy	4.1
B. Test Accessioning	
Ease of Test Order Entry	2.6
Label Generation	3.0
Worksheet Clarity	3.6
C. Results Report	
Print-out Clarity	4.0
Results Entry	2.9
Inquiry Capability	3.7
Hard-Copy Results Availability	3.1
File Edit Capability	3.4
D. Efficiency	
Abnormals Identification	3.1
Department Log	2.5
Medical Staff Familiarity	2.7
Training	2.9
E. CRT Functions	
Screen Legibility	4.5
Command Functions	3.3
Terminal Locations	2.7
F. Results	
Data Quality Control	3.4
Results Accuracy	3.9
Quality Control Reporting	3.2
G. Information Storage and Retrieval	
Verifying Patient ID	2.7
Results Retrieval	2.8
Results	3.4
Cumulative Results	3.2
Overall Satisfaction	
With TRILAB	2.4
Laboratory Services	3.6

[a]Using the Likert scale.

TABLE 24

FREQUENCY OF PROBLEM OCCURRENCES
POST-IMPLEMENTATION PERIOD SURVEY OF LABORATORY PERSONNEL AT NRMC OAKLAND

	Often	Occasionally	Rarely	Never	No Opinion
Tests repeated due to lost results	0.1%	42.1%	42.1%	13.2%	2.6%
Duplication of information	21.1	28.9	36.8	2.6	10.5
Telephone calls to units	5.3	73.7	15.8	2.6	2.6
Time spent on manual record keeping	44.7	28.9	15.8	2.6	7.9
Time spent telephoning STAT results to unit	13.2	40.0	28.9	2.6	5.3
Errors in transcription	15.8	44.7	23.7	5.3	10.5

- duplication of information occurred rately (37 percent);
- telephone calls to units occurred occasionally (74 percent);
- errors in transcription also only occurred occasionally (45 percent); and
- time spent on manual record-keeping, however, occurred "often" (45 percent).

When asked to compare operations under TRILAB with manual operations prior to installation of TRILAB (Table 25), respondents (who had been with the laboratory prior to installation of TRILAB) indicated that the following occurred less frequently with TRILAB:

- telephone calls to providers (73 percent); and
- time spent on manual record-keeping (47 percent).

The following were judged to occur with similar frequency under TRILAB:

- repeating tests due to inaccurate results (53 percent); and
- transcription discrepancies (43 percent).

TRILAB Improvements. Respondents were asked to identify the relative importance of improvements due to TRILAB (Table 26). Respondents felt that improvement in format of laboratory requests/results was either somewhat important (30 percent) or somewhat unimportant (30 percent).

Improvement in efficiency of laboratory operations was considered somewhat important (34 percent). Most respondents were undecided about accuracy of results under TRILAB (36 percent), but felt that improvement in ease of information storage and retrieval was very important (46 percent); respondents assigned a higher value to this aspect in this question than implied in a previous question (Table 23, item G). Improvement in number of telephone calls was judged either somewhat important (40 percent) or very important (30 percent).

Instrumentation. In response to the question "Are there any instruments which should be on-line to the TRILAB system but are not now?", the two instruments mentioned most often were the Coagamate (suggested by seven respondents) and the Differential Counter (mentioned by five respondents). The Gemini (four respondents) was also suggested. (Interfaces were available for the Coagamate and Gemini, but were not being utilized.)

TABLE 25

COMPARISON OF TRILAB WITH MANUAL OPERATIONS
POST-IMPLEMENTATION PERIOD OF LABORATORY PERSONNEL
NRMC OAKLAND

	Change in Frequency (Percent of Respondents)				
	More Frequently With TRILAB	Similar Frequency	Less Frequently	Never with TRILAB	No Opinion
Telephone calls to inpatient units/ outpatient clinics	6.7%	20.0%	73.3%	0%	0
Duplication of information	20.7	17.2	41.4	10.3	10.3
Necessity of repeating tests due to inaccurate results	3.3	53.3	30.0	13.3	10.0
Time spent on manual record keeping	20.0	33.3	46.7	0	0
Discrepancies in transcription	23.3	43.3	20.0	3.3	10.0

TABLE 26

IMPROVEMENTS DUE TO TRILAB
POST-IMPLEMENTATION PERIOD SURVEY OF LABORATORY PERSONNEL AT NRMC OAKLAND

	Percent of Respondents Expressing Opinion				
	Very Important	Somewhat Important	Somewhat Unimportant	Very Unimportant	Undecided/ No Opinion
Format of lab requests/results	10.8	29.7	29.7	10.8	18.9
Efficiency of laboratory operations	14.3	34.3	5.7	17.1	28.6
Accuracy of results	25.0	13.9	5.6	19.4	36.1
Ease of information storage and retrieval	45.9	37.8	5.4	2.7	8.1
Number of telephone calls	29.7	40.5	5.4	2.7	21.6

Two respondents indicated that the C-800 should not be on-line, and one respondent indicated that the SMAC should not be on-line.

Additional Comments. The most frequent additional comments were the following:

- System Too Slow. The comment made most often (by 16 respondents) was that the system was too slow for accessioning and entering results, particularly at certain peak times of the day. Respondents specifically mentioned the fact that increased memory was required.
- Down Time. Six respondents made the comment that the computer system broke down too often, increasing the workload due to resultant recording of results.
- Preventive Maintenance. Four respondents objected to preventive maintenance being performed during the day, when utilization was the highest, instead of on evenings or weekends.

On the positive side, advantages cited were easier access to results (three respondents) and fewer telephone calls (two respondents). Five respondents, however, felt that the TRILAB computer system resulted in extra work for the laboratory.

d. Comparison of Satisfaction Ratings in Baseline and Post-Implementation Periods

Users. Table 27 compares the average satisfaction ratings with laboratory services between the two study period surveys. Average scale ratings by physicians increased by 0.4 to 0.6 for the following aspects of laboratory services:

- accuracy of results;
- legibility;
- length of time between routine tests and results; and
- length of time between STAT tests and availability of results.

Completeness of results and overall laboratory performance received lower rating increases (0.3 and 0.1, respectively).

TABLE 27

COMPARISON OF USER SATISFACTION RATINGS WITH LABORATORY SERVICES
BASELINE AND POST-IMPLEMENTATION PERIOD SURVEYS AT NRMC OAKLAND

	Mean Satisfaction Rating[a]								
	Physicians			Nurses and Physician Assistants			Other Users (administrative)		
Service Aspect	Base-line	Post-Imp.	Difference	Base-line	Post-Imp.	Difference	Base-line	Post-Imp.	Difference
Accuracy of results	3.7	4.1	0.4	3.4	4.2	0.8	NDA	4.1	NDA
Legibility/clarity	3.9	4.5	0.6	3.9	4.6	2.7	4.0	4.4	0.4
Completeness of results	3.9	4.2	0.3	3.4	4.2	0.8	3.1	4.1	1.0
Length of time between routine tests and results	3.2	3.6	0.4	2.7	3.5	0.8	NDA	3.3	NDA
Length of time between STAT tests and results	2.8	3.3	0.5	2.8	3.0	0.2	NDA	3.4	NDA
Overall laboratory performance	3.6	3.7	0.1	3.4	3.5	0.1	3.8	3.6	-0.2

[a] Likert scale.

Nursing staff showed a higher increase in average satisfaction ratings (0.7 or 0.8) for accuracy, legibility, completeness, and length of time between routine tests and results, and smaller increases in satisfaction ratings (0.1-0.2) for length of time between STAT tests and results, and overall laboratory performance.

Administrative users showed a large increase (1.0) in satisfaction rating for completeness of results, and a smaller increase in satisfaction with overall laboratory performance (0.1) and legibility (0.4).

These results indicate that user satisfaction with aspects of laboratory performance had increased with implementation of the TRILAB system. The degree of increase in satisfaction and particular area emphasized depended on the user category.

Clinical Laboratory Personnel. The baseline questionnaire included only questions related to general aspects of job satisfaction that are unrelated to implementation of the TRILAB system. Consequently, the results reported in Section c for the laboratory staff post-implementation questionnaire are believed to present the best assessment of laboratory staff comparative satisfaction.

As discussed above, laboratory personnel were overall less satisfied with the TRIMIS system than were providers, indicating that the system was frequently slow and had too much down time. On the positive side, however, laboratory staff indicated that manual record-keeping and time spent on phone calls had decreased, and that results retrieval was easier with the TRILAB system.

E. PATIENT SATISFACTION WITH LABORATORY SERVICES

1. Baseline Survey

In an attempt to measure satisfaction of patients with regard to laboratory services, the baseline study included a questionnaire survey of outpatients who use the services of the laboratory. For a period of two weeks, 25 forms were distributed daily to patients who came to the laboratory for blood drawing. The first week of sampling included morning visits, while the second week included afternoon visits. The volume of walk-in traffic was noticeably higher in the

morning and there was more success in having patients respond during this time. One hundred seventy-four patient questionnaires were returned, representing a response rate of approximately 70 percent.

The patient questionnaire included questions with regard to the patient's perception with regard to such factors as:

- courtesy of clinical laboratory staff;
- amount of time having to wait to register with the laboratory receptionist;
- waiting time;
- personal attention;
- amount of information given about a particular test and the adequacy of the instructions;
- competence of the laboratory staff and test results; and
- general satisfaction.

Patients were asked to indicate how satisfied they were and ratings of 5, 4, 3, 2, 1 were assigned (the Likert scale). The majority who responded (78 percent) were either retired or a dependent of a retiree.

Approximately 86 percent of respondents indicated that they had previously used the laboratory services. Approximately five percent indicated that they had had to have tests repeated because the results had not reach the physicians.

On average, no question had a satisfaction rating of less than 4.12. Overall the majority of patients were either satisfied or very satisfied with the services of the laboratory.

2. Post-Implementation Survey

During the post-implementation period survey, 200 questionnaires were also distributed to patients who came to the laboratory for blood drawing.

The patient questionnaire included questions with regard to patients' general satisfaction with clinical laboratory services, waiting time after registration, and waiting time for laboratory technicians.

Table 28 compares average patient satisfaction ratings reported in the two surveys. The laboratory received comparatively high ratings by patients in both study periods. The general satisfaction rating remained generally unchanged (4.5), as did satisfaction with waiting times for specimen taking (4.2) There was a decrease in satisfaction rating of waiting time required to register (from 4.5 to 4.1).

Patients were also asked to indicate whether they had to have tests repeated due to lost results or whether they experienced delays due to incomplete test request forms. Table 29 summarizes the responses. Most patients indicated that they "never" or "rarely" experienced such problems. Two to three percent indicated that they occurred "often."

About 22 percent of patients added comments to their questionnaire. The majority of these were laudatory, and referred to the "excellent service" received at the facility or that they had experienced no problems. Seven patients felt that the waiting times for service were excessive, or that it took too long to get a clinic appointment (three patients).

F. SYSTEM COSTS

The following estimates of costs of the TRILAB system are based on three sources: the vendor proposal for the system at NRMC Oakland, the monthly material inspection and receiving reports for the lease and maintenance of the systems, and interviews held with systems, laboratory and nursing staffs of the hospital.

Costs of the system are divided into one-time costs (including system acquisition, site preparation, set-up and training costs), and recurring costs (including system operating staff, data processing supplies, system maintenance and space costs).

1. One-Time Costs

a. System Acquisition

The laboratory system was purchased under a 13-month lease-to-ownership plan at a monthly charge of $39,182. The total cost of the hardware system, including mainframe and peripherals (42 CRTs, seven character printers and one line printer) was 13 months x $39,182/month = $509,366. Other one-time vendor charges were:

TABLE 28

COMPARISON OF AVERAGE PATIENT SATISFACTION RATINGS[a]
BASELINE AND POST-IMPLEMENTATION PERIOD SURVEYS AT NRMC OAKLAND

	Baseline	Post-Implementation	Difference
Time to register	4.5	4.1	-0.4
Waiting time for specimen taking	4.2	4.2	0
General satisfaction	4.6	4.5	-0.1

[a]Average of Likert scale ratings.

TABLE 29

ESTIMATED FREQUENCY OF PROBLEM OCCURRENCES
POST-IMPLEMENTATION PERIOD PATIENT SURVEY AT NRMC OAKLAND

	Other	Occasionally	Rarely	Never	Don't Know NA
Test repeated due to lost results	2.0 %	15.3%	23.0%	53.1%	6.6%
Delay due to incomplete test request form	3.1	7.3	19.2	63.2	7.3

System installation	$ 48,895
Software	188,897
Documentation	15,790
Training	21,053

The total system acquisition cost was therefore $784,001.

b. Site Preparation

The cost of preparing the computer room for the TRILAB and other computer systems was $163,000. In addition, it was planned to upgrade the air-conditioning and power supply to the computer room in December 1982; the cost of site upgrade was estimated at $165,000. Total cost of site preparation was therefore $328,000. Since the computer room will support several systems, 30% of the site preparation costs was allocated to TRILAB. Site preparation cost was therefore estimated at $100,000.

c. Other Equipment

The MIS Department purchased additional anchors for the terminals ($806) and video tape ($453) for the system, for a total of $1,259.

d. Systems Staff

During installation and implementation of the system, six-man-months of analysts were involved (four man-months of an analyst GS 11 and two man-months GS 12: ((4 x $3,179*) + (2 x$3,560*) = $19,836.

e. Training Time

The following categories of hospital staff received training on use of the system, during their normal duty hours. The estimated costs of the staff time involved are presented below:

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*Civilian salaries from Federal Employees' Salary Scale (FY '82) Step 4. Includes leave allowance of 20.9% and fringe of 21.7%. Military salaries include base pay from annual composite salary schedule (FY '81) adjusted by the percentage increase reported for FY '82 (Army Times, October 18, 1981. Rates were adjusted by leave allowance of 20.9% and 38% fringe plus quarters and other special pay. Quarters and other special pay were assumed to increase at the same rate as base pay.

Computer Operators. Five computer operators (GS 7 level) received 24 hours of training each. The staff time salary cost therefore was: 5 x 24 x $12.39* = 1,487.

Laboratory Staff. Approximately 45 laboratory staff received about five hours of training each on use of the system, for a total of 225 hours. In addition, senior laboratory staff spent approximately 70 hours in training physicians to use the terminals for inquiry, on a one-on-one basis. The total estimated time cost was 295 x $11.01 = $3,248.

Nursing Staff. One hundred-eleven members of the Nursing Department staff received one hour of formal training each. At an average hourly salary of $13.11*, the salary time cost was 111 x $12.68* = $1,407.

Physicians. As discussed above, approximately 70 physicians received one-on-one training from laboratory staff. Assuming an average 0-4 grade and one hour training, the time cost involved was 70 x $30.31 = $2,122.

Total. Total estimated cost of staff time involved in training was therefore $8,264.

File Building. Laboratory staff time involved in building the initial data files was estimated to total 120 days. At an average daily cost of $88.15*, the total staff time cost was 120 x $88.15 = $10,758.

The total one-time cost for installation and implementation of the TRILAB system at NRMC Oakland, as summarized in Table 30, was $856,000.

2. System Operating Costs

a. System Maintenance

The initial monthly system maintenance costs were:

Hardware	$2,418
Software	1,390
Communication lines	558
Total	$4,096

*See footnote page 75.

TABLE 30

ONE-TIME TRILAB SYSTEM IMPLEMENTATION COSTS
NRMC OAKLAND

Cost Item	Cost
System Acquisition	$784,001
Site Preparation	100,000
Other Equipment	1,259
Systems' Staff Time	19,836
Staff Training Time	8,264
File Building	10,578
Total	923,938

Hardware maintenance was scheduled to increase annually by 7 percent, 7 percent, 9 percent, 9 percent, 12 percent, 13 percent, and 14 percent on July 1, 1982 through July 1, 1988. Communication line maintenance cost was scheduled to escalate at 10 percent per annum commencing July 1, 1982. Software maintenance cost was not subject to escalation (a 75 percent discount will be applied for months 50 through 96 of the systems' life if all "mandatory and optional systems" are purchased it; it is not expected that this clause will be operative). The projected schedule of maintenance cost is shown in Table 31.

b. Space Costs

The allocated annual space cost for the computer room at NRMC Oakland was $5.71/sq. ft. for 1,560 sq.ft., or $8,908. There are currently three computer systems; it is planned that there will be ten systems within four years. The space costs were, therefore, estimated at $2,969 annually for the first three years and $891 per year thereafter.

c. Staff Costs

Analyst. A full-time analyst (GS 11) was devoted to maintenance of the system. The annual cost was therefore $38,142.

Operators. The equivalent of 56 hours per week of operator time (GS 7) were allocated to the system. The annual cost was therefore 52 weeks x 56 hours x $12.39 = $36,080.

The total annual system staff costs were therefore $74,222.

d. Supplies. Estimated costs of supplies (primarily computer report paper) was $14,000.

The total estimated initial annual recurring system costs were therefore $140,343, as shown in Table 32.

TABLE 31

TRILAB ANNUAL COMPUTER MAINTENANCE COSTS
NRMC OAKLAND

	Hardware	Software	Line	Total	Annual
Initial	$2,148/mo.	$1,390/mo.	$ 558/mo.	$4,096/mo.	$49,152
July 1, 1982	2,298	1,390	614	4,302	51,614
July 1, 1983	2,459	1,390	675	4,524	52,288
July 1, 1984	2,681	1,390	743	4,814	57,768
July 1, 1985	2,922	1,390	817	5,129	61,548
July 1, 1986	3,272	1,390	899	5,561	66,732
July 1, 1987	3,698	1,390	989	6,077	72,924
July 1, 1988	4,216	1,390	1,087	6,693	80,316

TABLE 32

ANNUAL RECURRING TRILAB SYSTEM COSTS
NRMC OAKLAND--1982

Maintenance		$ 49,152
Space		2,969
Systems' Staff		74,222
Supplies		14,000
	Total	$140,343

IV. DISCUSSION OF RESULTS

A. SYSTEM BENEFITS

In this section the benefits that have accrued as a result of the TRILAB system are summarized. First the benefits that can be quantified are presented, and then the benefits which cannot be quantified. The benefits are based on:

- interviews with providers and laboratory staff, carried out during implementation monitoring visits and the post-implementation survey;
- data collected as part of the post-implementation study.

1. Inpatient Units

Work sampling was not carried out during the baseline evaluation in user locations. In order, therefore, to obtain estimates of benefits to users (health care providers) of the TRILAB system, interviews were held with nursing staff (RNs and ward clerks) of six inpatient units, which had a TRILAB terminal for results reporting and inquiry.

Benefits were described as follows:

- Reduced Time on the Telephone. This included the time that nursing staff spent on the telephone to receive test results and to inquire about late or missing results. Nursing staff estimated that availability of the terminal saved an average of 3-1/2 hours per (24-hour) day per unit.
- Filing Time. It was estimated that having cumulative reports saved on average 1/2 hour per day per unit in filing, compared to the previous system of filing the individual requisition/ results slips.
- Chart Review. Staff of one unit estimated that availability of cumulative reports saved 1/2 hour per day in chart review, compared to having to go through a number of filed results slips.

It was thus estimated that on average 4 staff hours per inpatient unit per day were saved, which were made available for patient care or other activities.

Since 12 inpatient units have terminals, it is estimated that 48 hours per day of nursing staff (RN/corpsman/ward clerk) time, equivalent to 4 FTEs, were saved per day on inpatient units at NRMC Oakland, due to availability of the system.

- Duplicate Tests. The nursing staff estimated that an average of 3.5 duplicate tests per week per unit were avoided, through being able to determine the status of laboratory test requests and results. For the 12 nursing units having terminals, it was estimated that approximately 42 duplicate tests per week have been avoided as a result of the system.

2. Outpatient Services

Nursing staff in the emergency room and four outpatient clinics that have TRILAB terminals were interviewed in order to obtain their estimates of benefits achieved due to implementation of the TRILAB system.

Nursing staff estimated that in total an average of 4.6 hours of staff time per clinic per day were saved, due to availability of TRILAB. The major source of savings was in reduced time required for telephoning the laboratory (2.8 hours per day). The remaining savings were due to reduced time spent visiting the laboratory to obtain results or determine status of tests, in filing and in looking up results.

Since there were six outpatient clinics (including the ER) with terminals, the estimated savings in staff time were 6 x 4.6 = 27.6 hours of staff time per day (3.5 FTEs).

3. Other User Benefits

a. Nursing Staff

Nursing staff cited the following benefits, in addition to those described above:

- Improved Morale. As a result of being able to look up test status on the terminal, and the reduction in telephone calls to the laboratory, relationships between nursing and laboratory staff had improved considerably. This had improved morale of nursing staff.

- Decreased Turnaround Time. Turnaround time for test results, especially for routine tests, had been reduced, contributing to the reduction in telephone calls and improvement of relations with the laboratory. This may also have resulted in improved patient care.
- Identification of Abnormals. Because abnormal results were identified (by an asterisk), leading to faster and easier identification of patient problems, patient care has been improved.
- Discontinuance of Flow Sheets. Since the laboratory test report formats are cumulative, some nursing units have discontinued the manual charting of "flow sheets." Other units, however, preferred to maintain them because of their more concise format compared to the computer reports.

b. Physicians

Informal interviews were held with a number of physicians. Physicians were generally pleased with the system, once most of the "bugs" had been worked out of the system. In general, the house staff (residents and interns) who take care of the inpatients, tended to be very pleased with the faster availability of results via terminal inquiry, thereby avoiding the considerable number of phone calls that were previously necessary. Clinic physicians tended to have mixed reactions depending on the extent to which they relied on terminal inquiry, versus review of hard-copy results. Some clinic physicians found it easier to use the terminal to look up patients' results, whereas other physicians preferred to utilize hard-copy reports.

The following benefits were cited by physicians:

- Reduction in Telephone Calls. The number of telephone calls to the laboratory had dropped considerably. It was now necessary to call only when either the computer was down, or they needed information for patients who were seen more than 30 days ago.
- Improved Turnaround Time. Hard-copy reports did get back sooner but this did not mean that the outpatient chart was more often complete (presumably due to the workload in the Medical Records Department).

- Improved Quality of Care. Quality of care had improved because of the report format, including flagging of abnormal values and inclusion of some test results in the daily cumulative summary report which were not included in the flow sheets. Routine values were now available earlier (via terminal inquiry) than before TRILAB.

To summarize, both the interviews and the questionnaire survey (III-Section D) indicated that health care providers were generally pleased with the TRILAB system, citing as advantages reduced telephone calls, decreased turnaround times, improvements in relationships with laboratory personnel, and improvement in quality of care due to easier and faster access to test results, identification of abnormal values, and cumulative report formats. A further indirect measure of approval of the system was the expressed desire of staff in those inpatient units and outpatient clinics that did not have terminals (and had to share a terminal in another location) for a terminal in their own location.

As indicated in Section D, the major problems or improvements identified by providers were:

- addition of Nuclear Medicine results to the system;
- improving the format of reports to reduce paper volume; and
- reducing computer down-time disruptions.

4. Benefits Achieved in Laboratory

The following discussion of benefits of the TRILAB system to laboratory staff is based on interviews carried out with laboratory administration and supervisors during the implementation monitoring and post-implementation period study data collection visits. Laboratory staff identified the following benefits from the system:

- Reduced Telephone Calls. It was estimated that telephone calls to the laboratory had been reduced by about 50 percent, because of availability of results and test status to providers via terminal inquiry. The study of telephone call volume (Section III-2) indicated that telephone

call volume decreased by 43 percent. This resulted in less time in actually answering calls and a reduction in the disruptions in the laboratory work flow.

- Workload Reporting. Supervisors estimated that in the three major sections (Chemistry, Hematology, and Microbiology), approximately 8.5 hours per week in total were saved by having the TRILAB system produce the monthly workload reports; these reports were previously prepared manually. (This compares with the reduction of 21 hours estimated using the work sampling study data.)
- Quality Control Reports. Supervisors similarly estimated that 11 hours per week were saved in producing the quality control reports, which were produced by the TRILAB computer system. (This compares with 31 hours per week saved estimated using the work sampling study data.)
- Patient Exception Reports. It was estimated that approximately 10 hours per week were saved in review of patient exception reports, due to the highlighting of abnormal results by the computer system.
- Reception Desk. As a result of removal of the results files from the reception area, and the fewer number of telephone calls to the laboratory, it was possible to reduce the number of staff at the reception area from 1.5-2 to 1-1.5; that is, a savings of 0.5 FTE was achieved at the reception area.
- Duplicate Tests. The number of duplicate or repeated tests have been reduced with the TRILAB system for two reasons: (1) providers could easily check on the status of tests, and would be less inclined to repeat an order if they saw a test was pending or in process; (2) abnormal results and unusual "delta checks" (abrupt changes from the previous day's results) showed up on the screen as they were entered, so that extra attention was given to such results, which may have resulted in fewer result report errors.

No data were available on the frequency of duplicate or repeat tests, but supervisors estimated that there might be a reduction of approximately one percent in total tests because of the improvement. This would approximate a reduction of about 450 tests per week based on the current workload. This compares with the reduction of 40 or 50 duplicate tests per week avoided, estimated by inpatient nursing staff (Section 1 above). To be conservative, it is estimated that 100 duplicate tests per week may be avoided, representing about 0.2 percent reduction in total tests.

In addition to the above (quantifiable) estimates of benefits, laboratory staff cited the following benefits:

- Reduction in Transcription Errors. Because abnormal results were highlighted on the CRT screens, and received extra scrutiny by technicians and reviewers, there was potential for reduction of transcription errors. In addition, the Microbiology section had found that the computer-generated "infection control report," which lists Microbiology results by patient, had enabled the section to identify result report format errors. These errors were mostly clerical--that is, where the wording of results could have been improved; only one "blatant" error had been detected during the period of system operation. Thus this review capability, which was not available in the manual system, was used mainly to educate technicians to improve their reporting of Microbiology results.
- Normal Ranges Data. The system provided the capability to provide normal ranges data with each test (which is a CAP accreditation requirement). This was not provided previously, at least for the majority of tests for which the users were expected to know what the normal ranges were.

- Search Capability. The availability of the computerized data base of test results and associated demographic data, provides the potential capability of performing a variety of analyses with regard to utilization, epidemiologic analysis, etc. This capability has not been utilized as yet.
- Management Reporting. At the time of the post-implementation study, the workload reporting system was being enhanced to provide a more detailed analysis of workload by section, shift and day of week, and analysis of workload per assigned (FTE) staffing. This would enable laboratory management to improve the allocation of staffing resources in response to workload, and thereby improve the overall efficiency and effectiveness of laboratory services.

B. RECOMMENDATIONS TO ENHANCE BENEFITS

The following section presents suggestions on potential improvements to the TRILAB system, based on observations and interviews with data processing, laboratory, and provider staff at NRMC Oakland. These suggestions may be useful for other institutions, as well, for which implementation of the system is being considered.

1. Memory Capacity

One of the major difficulties with the TRILAB system at NRMC Oakland was that the on-line memory capacity of the computer system appeared to be significantly undersized. This evidenced itself in a number of ways:

- It was possible to maintain only 30 days of patient results data on the system for on-line inquiry, compared with the original specification for 6 months of patient results. As a result, physicians reported difficulty in retrieving results for long-term patients who were seen at intervals of more than 30 days. Also, laboratory staff spent additional time in loading in patient identification data for prior patients who had been removed from the active file.
- System response was degraded at certain heavy-use times of the day, usually between 0900 and 1100, and between 1300 and 1500 hours. The main problems were felt in the

laboratory, where test acquisitioning and result inputting were slowed down. Providers also found that response time to inquiries was degraded.

- The times of the day during which the line printer may be used to print major reports was severely restricted, in order that the other system functions not be affected. (Improving the printing capacity may require a combination of a higher speed printer, increased memory, and changes in software.)

2. Report Formats

The number and format of reports has gone through some evolution since original implementation of the system. As is often the case with implementation of computer systems, once users become familiar with the capability of the system they tend to ask for additional and more detailed data and reports. After a period of time, however, they find that some of the additional data or reports are redundant or not needed. In particular, many users commented on the fact that some of the reports should be more concise in order to eliminate the volume of paper, and that some data could be usefully omitted. It would be useful to review with users their specific needs, in order to determine whether any of the reports could be improved in format, or reduced in content.

3. Need for More Terminals

Again it is not a surprising result that, after usefulness of the system has been demonstrated, particularly results reporting and inquiry capabilities, those user locations which did not have terminals should desire one. In addition, it may be useful to consider terminals for remote locations served by the laboratory, in order to improve their report results turnaround times.

4. Operational Problems

Although the TRILAB system functioned in accordance with expectations, there were a number of problems which persisted, which if eliminated would reduce some frustrations associated with system operations. These include, for example, inappropriate beeping of

terminals, repeat results reporting, and systems' maintenance being carried out during the daytime. Continued attention to solving such problems will improve its acceptance and usefulness and reduce any frustrations experienced with the system.

C. CONCLUSIONS

The analysis of the data collected for this evaluation suggests that the TRILAB system has generally met the overall objectives and evaluation criteria originally developed for the system. Hospital staff are generally pleased with the system, with providers expressing greater satisfaction and receiving greater benefits than laboratory personnel.

The major benefits of the system were:

- Improved turnaround time for test results, most markedly in availability of results for routine Chemistry and Hematology tests.
- A reduction in time spent by inpatient and clinic staff in telephoning for test results and test status. This reduction in staff time was estimated to total 76 staff hours per day, equivalent to 9.5 FTEs, made available for other activities.
- Laboratory results were more easily available to providers (via terminal inquiry) and in more useful format (provision of cumulative reports and highlighting abnormal results), which may improve quality of patient care.

Indirect indicators of approval of the system by providers were the requests for terminals for those locations which did not have them, and that Nuclear Medicine (which is not now on the system) be added as soon as possible.

The benefits to laboratory personnel included a reduction in staff time devoted to information handling activities, a reduction in telephone calls to the laboratory, and increased capability to improve efficiency and effectiveness of service through the workload/-management and quality control reporting capabilities.

D. COMPARISON OF RESULTS WITH PROJECT OBJECTIVES

On July 15, 1977, the TRIMIS Medical Review Group (MRG) developed seven project objectives for the TRI-Service Laboratory System[5]. In this section, the results obtained in the evaluation at NRMC Oakland are related to these original objectives.

1. To Make Information Available to Physicians with Increased Efficiency and Accuracy

Providers reported that turnaround time for test results had decreased with the TRILAB system; this was confirmed in the analysis of turnaround times. The turnaround study showed that for routine tests, results were available to provider locations in less time for Chemistry and Hematology tests, and in about the same time period or sooner for Microbiology. For STAT/urgent tests, process times were either unchanged (Chemistry) or reduced.

Tests repeated due to delays or to lost results, and telephone calls to the laboratory were also reported to occur with less frequency under the operation of the TRILAB system than with the previous system. These indicators suggest that information was being made available to physicians with increased efficiency. Data were not available to make a comparison of accuracy of results; laboratory personnel believed, however, that accuracy of results may have been improved because of highlighting of unusual results values by the system, facilitating review of such results. Most providers felt, however, that repeating of tests due to inaccurate results occurred with similar frequency with the TRILAB system as before.

Providers, especially those on inpatient services, were very satisfied with the ability of retrieving patient laboratory results via terminal inquiry, and with the cumulative results reports. In some cases the cumulative reports were used to supplement the manual "flow sheets," and in others had replaced them. Nursing personnel estimated that, on average, four staff hours per inpatient unit per day had been saved, through reductions in time on the telephone, filing time, and chart review. In addition, an average 4.6 hours of professional and clinical staff time per clinic per day were estimated to be saved.

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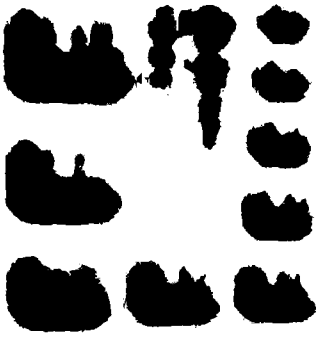


2. To Present the Data in a Convenient and Meaningful Manner with Sufficient Variety in Report Formats to Meet the Needs of All Users

With the addition of the interim report for pre-operative patients, the main needs of providers have been met.

There are several areas in which report formats could be further improved:

- addition of patient phone numbers and addresses to outpatient reports to facilitate notification of patients;
- more concise report formats, in order to reduce the amount of paper; and
- addition of Nuclear Medicine results to the system.

Both physicians and nursing staff indicated significant increase in their satisfaction with legibility of laboratory reports between the two study periods (by 0.6 and 0.7 average scale rating, respectively).

3. To Be Able to Handle Increased Demands for Laboratory Testing Without Significant Increases in Staff

The evaluation results indicate that somewhat less time of laboratory staff was being devoted to clerical activities, such as workload reporting, quality control reporting, and transcription and recording of test results, on telephone calls, and in number of staff required at the reception area. The percent of time devoted to processing of test results increased by a (modest) 1.2 percent. These results suggest that the TRILAB system will increase the ability of laboratory personnel to handle increased demands without significant increases in staff, but this increased capability will be modest.

4. To Provide Accountability of Laboratory Requests and To Monitor Generation of Test Results to Include Providing Notices of Abnormal Values or Improper Quality Control Results as Soon as They are Available

The system provides immediate highlighting of abnormal values and unusual changes from previous results, facilitating review by laboratory personnel and pathologists. This objective is therefore considered to have been met.

5. To Gather as a Result of Normal Procedures, Workload and Managerial Data, and to Present This as Required in Order to Assist in Decision-Making in the Laboratory

The system gathered and presented workload data (thereby reducing the time devoted to this activity). The workload report was being modified to enhance its capability to provide workload and managerial data, which should lead to improved capability of allocating laboratory resources in response to required workload.

6. To Reduce the Clerical Work Required of Qualified Technicians in the Laboratory

The work sampling results indicate that, overall, time devoted to information handling activities was about 6 percent less in the post-implementation period compared with the baseline period; this difference was about 2.6 percent of total laboratory technician staff time. Laboratory personnel indicated that identification of incomplete and pending tests and results was improved by the TRILAB system and that time spent on manual record-keeping occurred less frequently with the TRILAB system. They reported that "efficiency of laboratory operations" and "ease of information storage and retrieval" were either "very important" or "somewhat important" improvements due to TRILAB.

The major change in non-personnel operating costs in the laboratory was likely due to a reduction in duplicated tests, and the associated reagent costs. Providers and laboratory staff estimated that the reduction might have been approximately 100 tests per week.

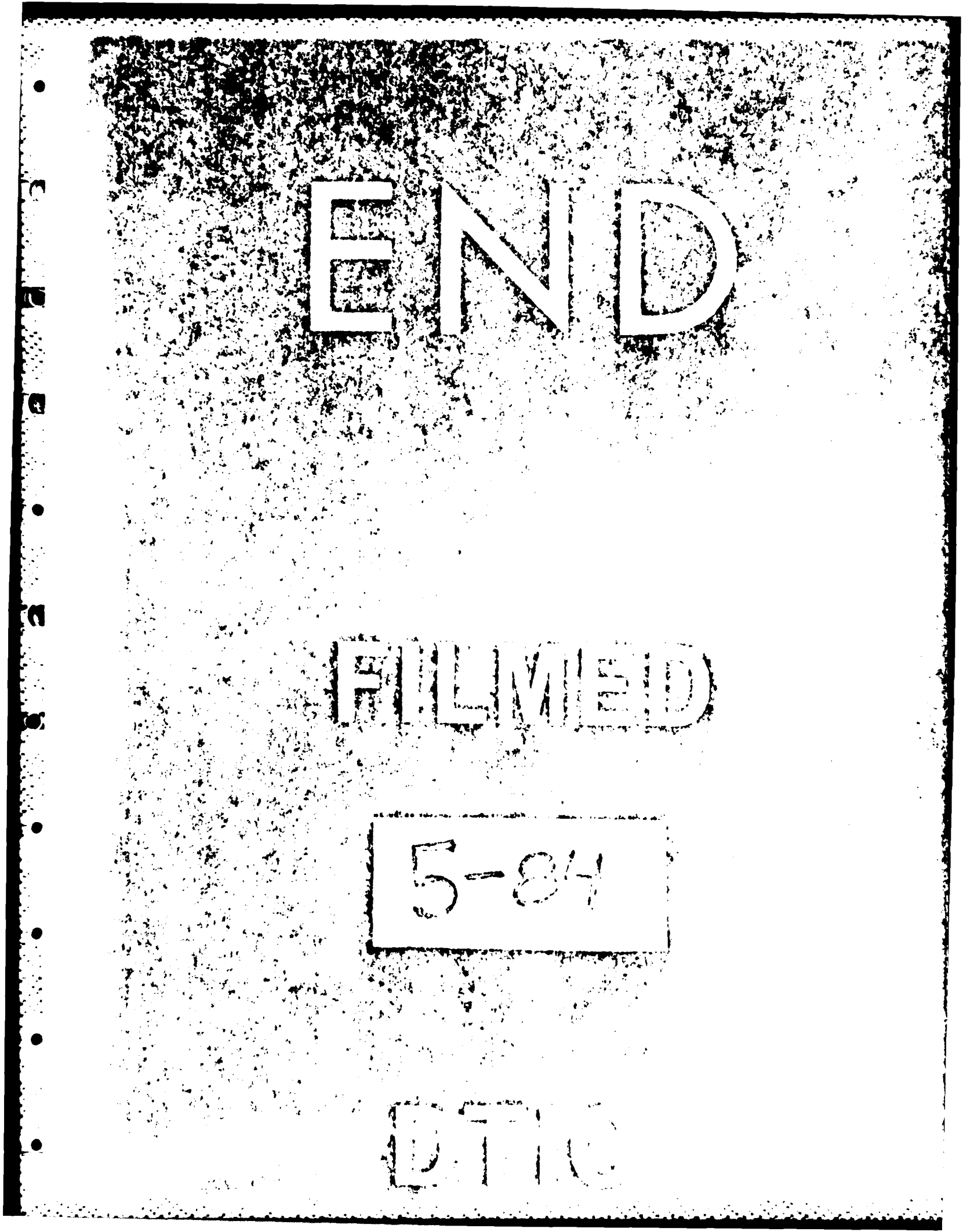
7. To Improve Result Accuracy by Eliminating Transcription, Calculation, and Specimen Identification Error

No data were available to measure this effect. Both providers and laboratory staff, however, believed that such errors have been reduced, resulting in fewer duplicate tests requires.

It is concluded that the original project goals have been by and large met, albeit modestly for the objectives of enabling the laboratory to handle increased demands for testing and for reducing the clerical work required to laboratory technicians.

REFERENCES

1. Analytic Services, Inc., The Evaluation Plan (Pre-Period X) for the Tri-Service Laboratory Initial Capability Information System, Contract MDA 903-78-C-0085, Report to TRIMIS Program Office, Bethesda, MD, June 30, 1980.
2. Analytic Services, Inc., Progress Report, Period X Data Analysis for the Evaluation of the Tri-Service Laboratory Initial Operating Capability System (TRILAB) at the Naval Regional Medical Center, Oakland, CA, Contract MDA 903-78-C-0085, Report to TRIMIS Program Office, Bethesda, MD, January 1981.
3. Arthur D. Little, Inc., Baseline Evaluation of the Tri-Service Laboratory System, Contract MDA 903-81-C-0209, Report to the TRIMIS Program Office, Bethesda, MD, August 1982.
4. Arthur D. Little, Inc., Plan for the Y Period Evaluation of the Tri-Service Laboratory System (Draft), Contract MDA-903-81-C-0209.
5. TRIMIS Program Office, Initial Project Objectives and Evaluation Criteria, September 1, 1977.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